THE CHILDREN'S HOSPITAL
BOSTON 1869

PROPERTY OF SURGICAL OFFICE
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TRAUMATIC SURGERY

BY

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WITH 522 ORIGINAL ILLUSTRATIONS

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PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1918

NAVAL
MEDICAL BACKGROUND
SERIES

Published February, 1917

Copyright, 1917, by W. B. Saunders Company

Reprinted April, 1917

Reprinted August, 1917

Reprinted November, 1917

PRINTED IN AMERICA

PRESS OF
W. B. SAUNDERS COMPANY
PHILADELPHIA

TO

MY WIFE

PREFACE

THIS book is written with the main idea of placing in one volume the information necessary to diagnose and treat all the usual and most of the unusual effects of accident and injury.

The profession at large has become reawakened to the problems of accident surgery, and, incidentally, has come into a new relationship with the injured because of the operation of compensation and allied laws; likewise, the victims of accident, and civic, judicial, legal, and other agencies are exacting from the physician a higher grade of care and placing on him an added burden of responsibility.

The writer has long been of the opinion that cases of injury have not received the same care and attention accorded other surgical patients, and has often realized that a properly treated Pott's fracture or infection of the hand is a far greater manifestation of the surgical art than the successful removal of an "interval appendix."

What follows is purposely didactic, and much of it relating to fractures has hitherto been the subject of clinical lectures to successive groups of matriculants at the Post-Graduate Medical School.

The text also aims to state the measures which the writer has found most practical in his own experience, and an effort has been made to unify and standardize the treatment of such common injuries as wounds, infections, burns, and the usual fractures. It will be noted that stress is placed on the routine use of but few antiseptics, the drainage of all wounds, the immediate and complete reduction of fractures, and non-reliance upon complicated splints or those that hide the part or are irremovable.

The writer believes that open air and sunshine is the best treatment for any infected wound in any location from any source, because purulent secretion is soon checked, there are no pus-soaked or wound adhering dressings (literally pus poultices), and the comfort of the patient is measurably increased and healthy granulations and minimum scarring occur promptly. For many years now this plan has been employed, and the writer is convinced that its efficacy is best

proved by the statement that skin-grafting has not been necessary since this form of aërotherapy and heliotherapy has become routine in his practice.

Many references are made to such recognized authorities as Stimson, Cotton, Cushing, Dana, and others; zealous effort has been made to accredit properly these and other sources of information, and if there is failure in this respect it is wholly unintentional.

The writer has had much encouragement and generous use of material from many of his associates in the various hospitals with which he is connected, and to these, and to successive members of respective house-staffs, he expresses sincere thanks. He is especially indebted to Drs. W. H. Stewart and I. S. Hirsch, radiologists respectively to Harlem and the Post-Graduate Hospital.

The publishers and their artist, Mr. J. V. Alteneder, are deserving of and are accorded acknowledgment for that co-operation without which the writer could not have called this a completed book.

This is an age of preparedness, and the writer cherishes the hope that this volume may, to some extent at least, better prepare his confrères, as it has him, to care for the patient who has been hurt—the many victims of these traumapathies.

JOHN J. MOORHEAD.

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NEW YORK CITY.

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TRAUMATIC SURGERY

CHAPTER I

WOUNDS AND THEIR COMPLICATIONS

WOUNDS

ALL such breaks in the continuity of the skin may be classified as *incised* and *lacerated*.

Incised wounds are smooth and more or less regular, and are best represented by cuts made by knives, glass, or sharp-edged materials.

Lacerated wounds are of many varieties, and they all are more or less ragged and irregular, and are usually due to falls upon edged projections or blows from more or less blunt objects. If the area is gouged or punched out, it is called a *punctured wound*. If it enters a deeper part or a viscus, it is known as a *penetrating wound*. If it shows bruising of the edges or parts adjacent, then it is called a *contused wound*. If only the superficial layer of the skin is scraped or rubbed, it is called an *abrasion;* and if this has occurred in part from friction, then it is called a *brush burn*, as from a rope sliding through the hands, or from contact of the moving body with a stationary object.

Symptoms.—All wounds show some signs of bleeding, gaping, pain, and sometimes swelling and discoloration.

Bleeding varies with the site, extent, and cause of the wound, and it is likely to be most active when the source is arterial or from a vascular territory. Incised wounds ordinarily bleed more than lacerated wounds because the vessels are generally cut cleanly across rather than more or less unevenly torn or bruised. Free bleeding generally follows wounds of the scalp (especially below the crown), face, fingers, palm, sole, scrotum, and tongue.

Gaping varies, and is most marked when the wound is deep enough to sever underlying fascial or muscular fibers.

Pain is less marked in incised than lacerated wounds, and it is most acute in sensitive areas and people. It may be entirely absent even with quite extensive damage, as in some amputations.

Swelling and *discoloration* are variable, but are most likely to occur in lacerated and contused wounds.

Treatment.—*For practical purposes any wound not made with surgical precautions should be regarded and treated as if already infected, irrespective of source, size, site, or symptoms.* The indications are to (1) stop shock and bleeding; (2) prevent infection; (3) provide coaptation, drainage, occlusion, and rest.

(1) *Shock* is ordinarily due to the bleeding, and after the wound itself is cared for, the usual systemic treatment is given for any existing collapse. Gentle manipulation is essential, and only the absolute necessities of the patient should be treated until shock is recovered from.

Bleeding is stopped by *pressure* applied directly to the bleeding spot by a clamp, the finger, or fabric; or indirectly, by cutting off the blood-supply by a tourniquet. It is exceedingly unwise to stop bleeding by styptics, as infection is almost certain to follow.

In emergency bleeding, finger pressure on the artery above the bleeding place will usually answer until a sterile compress can be packed into the wound or another form of tourniquet employed. An ordinary rubber band around a finger, forearm, arm, leg, or scalp makes an excellent tourniquet; and a garter, suspender, shoe-lace, or necktie acts almost equally well as a first-aid expedient when no twine or rope is at hand.

(2) *Infection* is prevented by allowing the wound to bleed a reasonable amount so that any foreign matter may be washed out; then pure tincture of iodin should be dropped into the cavity and allowed to cover the area about it by overflowing. If sterile materials are at hand, the bleeding should be checked before the iodin is used, so that it may be better absorbed. No scrubbing or other irritating measures should be employed. Oil and grease can be removed by kerosene, benzine, or gasolene. Hair should be removed from the margin of the wound. If iodin is not available, a solution of carbolic (1 : 100), bichlorid (1 : 1000), or pure alcohol may be used in the same manner. The chosen disinfectant should be made to penetrate every recess of the wound, especially if the parts are much crushed, mutilated, or stripped up. All bullet wounds, and those likely to be contaminated by soil, are guarded against tetanus infection by the immediate use of tetanus antitoxin. This is notably needful in "Fourth of July" injuries. Too much handling of these or other varieties is inadvisable, and probing is almost certain to prove disastrous.

(3) *Coaptation* is brought about by sutures of catgut (plain or iodized), horsehair, silkworm-gut, silk, or linen. Of these, silk and linen are most often used for emergency work. Ordinary sewing silk

Fig. 1.—Continuous suture method.

Fig. 2.—Coapting the angle of a wound.

Fig. 3.—Continuous suture method.

Fig. 4.—Continuous suture reinforced.

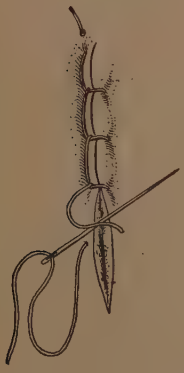


Fig. 5.—Continuous lock stitch.

Fig. 6.—Adhesive plaster strapping for coapting a wound.

or linen ("shoe-button thread") is just as good as the more expensive varieties (Figs. 1–5). Sterile adhesive plaster may be used in some cases (Fig. 6).

A good working scheme for the treatment of the average wound is the following:

Incised Wounds

Germ free.	Suture.	No drainage.
Germ present.	Suture.	Drainage.

Lacerated Wounds

Germ free.	Suture.	Drainage.
Germ present.	No suture.	Drainage.

Small wounds of the scalp sometimes may not need stitches if a few hairs on each side of the wound are intertwined and tied; this is particularly useful in women and children.

All stitches should be so placed that the wound edges *just touch* but do not overlap or jamb, otherwise necrosis will occur. Usually stitches are inserted about ½ inch apart on the face or actively mobile parts and 1 inch or more apart on other more quiescent areas. In most cases they may be removed not later than the fourth or fifth day, for, as a matter of practice, we know that wound edges properly coapted become well sealed after a lapse of a few hours. Metal clamps of the Michel type are unpopular in this country. Collodion makes an unsatisfactory and often dangerous primary dressing, but may later be of service.

Drainage should be used in every wound not made with surgical intent. Small wounds can be drained at one angle by a strand of the suture material inserted the full depth, and when this is removed, within a day or two, danger of infection will probably be past and such a small drain will not interfere with primary union. A twisted piece of rubber tissue or a small rubber band acts the same way.

Occlusion is best provided by sterile gauze, which may be dry in incised wounds and moist in other varieties. Absorbent cotton is objectionable next to the wound because it is not sufficiently absorptive and becomes adherent. Moist dressings may be made by placing the gauze in salt, boric acid, alcohol (25 to 50 per cent.), iodin (1 dram to a pint of water), or bichlorid (1 : 5000) solutions. Care should be taken not to bind the dressing too tightly, especially in wounds of the forearm, hands, and feet. In properly selected cases a gauze-covered wire cage over the open wound offers the best treatment so that there may be free access of air and sunshine; this is especially true of infected or secreting wounds. Collodion alone or in

the form of the familiar cotton-and-collodion dressing should not be used until all secretion has ceased and infection is improbable. Moist dressings must not be used too long as they macerate the parts, and usually a dry dressing can be substituted after a few days. The prolonged use of bichlorid may cause sloughing or poisoning. Carbolic solutions should never be used continuously.

Rest is provided by suitable bandaging that must not in any manner act as a tourniquet. In many cases a splint is advisable, and a suitable posture (usually elevation) will be an added factor of safety and comfort.

SPECIAL WOUNDS

Abrasions of the face, hands, and legs are very commonly due to grazing contact producing scraping wounds of the superficial skin

Fig. 7.—Extensive infected abrasion ("brush burn") of shoulder girdle region.

layers, often quite extensive, but without much bleeding. When much friction occurs, heat is generated and the edge of the abraded area may also show signs of a first degree burn (the so-called "brush burn," Fig. 7). These are apt to be painful, and numbers of them are infected by neglectful or self-treatment, especially "barks of the shin."

Treatment aims to prevent infection by the use of iodin liberally applied, and then the part is covered by a moist sterile gauze dressing of saline, boric, or alcohol solution. It is very unwise to use even a moderately strong antiseptic protective dressing in such a case because local resistance is much lowered and a relatively large surface

is exposed for absorption. Carbolic applications are almost certain to produce decided escharotic effects even in weak solutions, and, indeed, this drug (as hitherto stated) should not be used in acute surgical conditions except as a cauterant. Likewise, dry dressings, particularly of the collodion type, favor infection. A gauze-covered wire or other caging is the best form of protective, so that air and sunlight may have free access. If the area of denudation is very large, skin-grafting may be needed. When the serous oozing (or "weeping") has ceased, the use of balsam of Peru or scarlet red ointment will aid granulations. "Barks of the shin" need to be treated with the greatest care, so that periostitis and ulceration do not occur, especially in old people or when varicose veins or perhaps lues exist. In cases of this sort rest in bed with high elevation of the limb will be beneficial, especially in the early stages.

The systemic conditions often need as much attention as the local lesions.

CRUSHING WOUNDS

These are not infrequently associated with comminuted fractures, and more or less shock is a common accompaniment. The majority

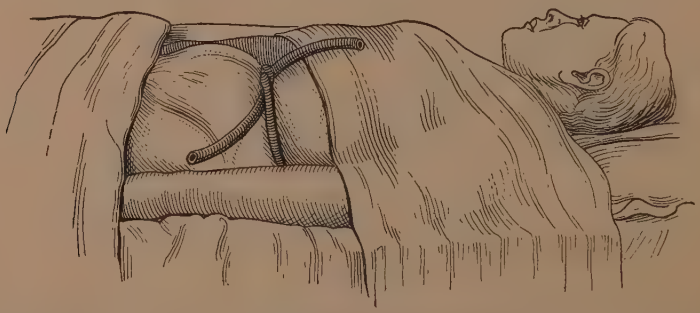


Fig. 8.—Momburg constrictor applied above the level of the umbilicus to restrict circulation through the abdominal aorta.

of these involve the hands, feet, or limbs, and are due to machinery, railway, vehicle, mining, building, and other transportation and industrial accidents.

Treatment is directed mainly to the bleeding and shock, and only the most necessary manipulation is made at first so that the patient's vitality may be conserved (Figs. 8, 9). In many cases, as in a crushed limb, the patient is put to bed for shock treatment with a tourniquet in place or artery clamps hanging to the vessels, the wound being covered by a sterile dressing (Figs. 10–13). Later, the appropriate

measures may be employed. In all instances the utmost gentleness must be employed, and much good will follow "blocking the nerves" by injecting the main or other visible trunks with 1 per cent. cocain, ½ per cent. novocain, or other analgesics. By such treatment the "anoci-association" idea of Crile is carried out and the dangers of

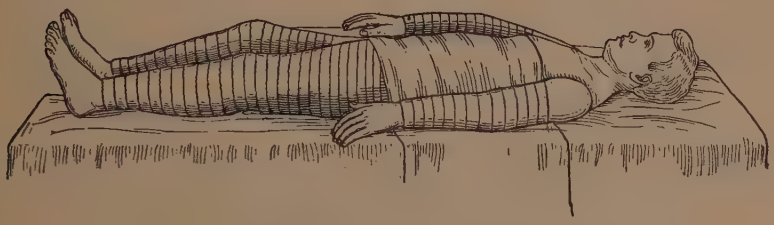


Fig. 9.—Bandaging the extremities to conserve the blood-supply in severe hemorrhage.

secondary shock greatly diminished. General anesthesia is of much aid, as in many cases of even profound shock it has a stimulating effect, ether being the anesthetic of choice, preferably used with oxygen.

The free use of iodin is the best disinfectant, and it should be poured fearlessly into every crevice of the wound until the surgeon feels cer-

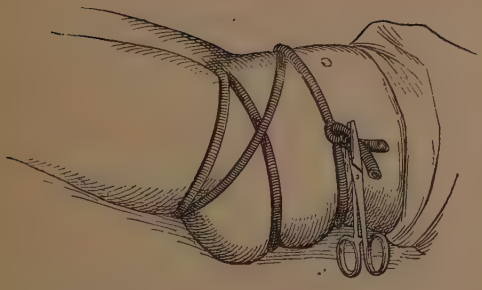


Fig. 10.—Tourniquet for the femoral vessels.

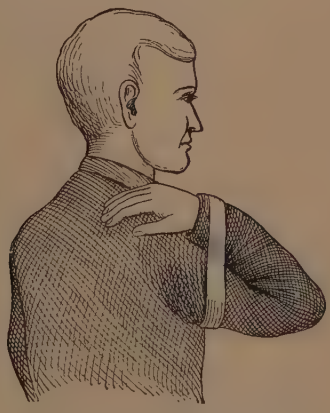
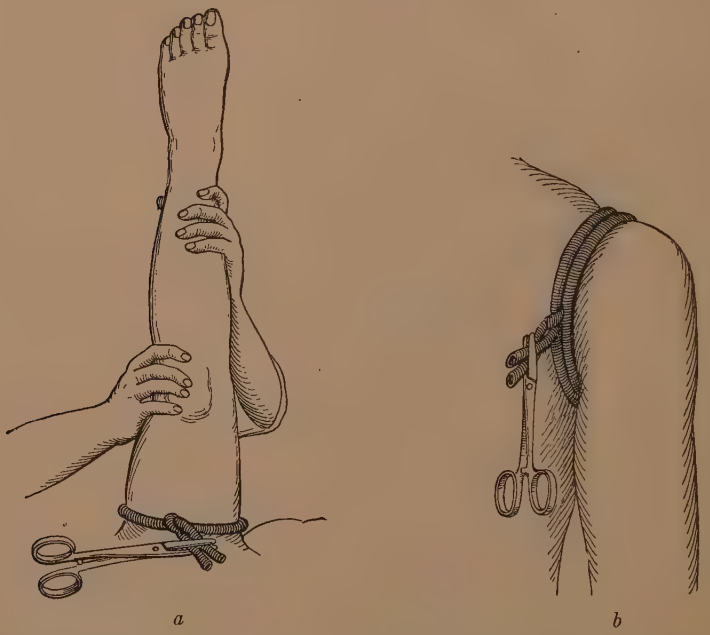


Fig. 11.—Hyperflexion of the elbow, acting as an improvised tourniquet for bleeding below the joint.

tain that he is working in an iodinized field. Gasolene, benzine, kerosene, olive oil, or albolene may be used to remove grease, but under no circumstances must vigorous scrubbing be undertaken. If there has been any possible infection from the soil, tetanus antitoxin should be given at once.

Conservation next to *sterilization* is the main requisite, and no tissue should be sacrificed unless absolutely necrotic or wholly detached from blood-supply. This is especially true in extensive wounds about the face, hands and feet, or in other localities where the blood-supply is known to be rich. Severed nerves and tendons should be united when possible, otherwise they should be marked for subsequent identification. Torn or pulpified muscle does not unite well and must be loosely coapted. Broken bones are held by strands of kangaroo tendon or otherwise placed in as good position as possible for subsequent treatment. No bony spicule is removed unless wholly detached from periosteum or obviously acting as a foreign body. Wiring, plating, or other metallic devices for bony junction are contra-indicated until the danger of infection has passed.



a *b*

Fig. 12.—*a*, Rubber tubing tourniquet on femoral vessels. *b*, Rubber tubing tourniquet on axillary vessels.

The soft parts are *loosely* sutured with horsehair, silkworm-gut, linen, or silk. Plentiful drainage is provided by strands of rubber tissue or rubber bands. A large loosely applied gauze dressing is moistened by saline, boric, alcohol, or other mild solution, and then the part is placed at rest on a well-padded splint. When the patient is abed the member is kept elevated and the dressing remoistened every

twelve hours by poking a glass syringe or irrigating tip into the meshes of the dressing and allowing the solution to flow from an irrigator, fountain or hand syringe. Shock is suitably treated. If possible, the patient is kept out of doors, and many of the cases do best with the wounded area exposed to the air and sunlight except for the gauze-covered wire screen previously mentioned.

Alcoholics need whisky and bromids until they sleep, begin to eat, and cease to show tremor of the tongue or fingers. The dressing need not be changed for twenty-four hours unless local pain or discharge demands, or constitutional developments indicate trouble. If now some of the parts are gangrenous or dead, they may be removed, but unless inflammatory reaction is very active it is advisable to wait as long as possible before excising supposedly dead soft parts, in the confident hope that at least some vitality will return. Drainage is gradually removed, and when the granulation stage is under way, balsam of Peru or balsam of tar may be used as a dressing.

Fig. 13.—Rubber tubing on middle finger and rubber band on little finger, acting as a tourniquet.

The *general* health of the patient is suitably cared for after the manner indicated under Infected Wounds.

AVULSIONS

In these cases the part is forcibly torn away, as the scalp from the skull or the arm from the shoulder (*disarticulation avulsion*). These accidents generally occur to persons working about revolving belts, gears, conveyors, huskers, or similar appliances (Fig. 14).

Scalping is commonest among women, and the entire scalp may be avulsed with the ears and eyebrows, or any portion of the hairy part may be removed, with or without a portion of the outer table of the skull. Bleeding is usually slight, but shock is often profound.

Treatment is primarily for the shock, and later autogenous skin-grafting will be necessary. Very occasionally an avulsed scalp has been replaced and some portions of it have successfully healed, but such cases are obviously only those in which the entire scalp is not denuded.

In the case shown (Fig. 15) the patient had been scalped by a moving belt, and one ear and both eyebrows were removed and two portions of the outer layer of the skull were also torn away. Skin-

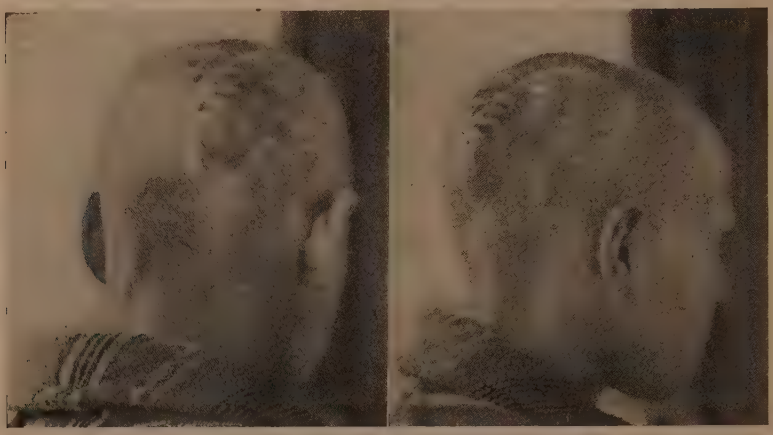


Fig. 14.—Partial avulsion of scalp.

grafts from friends and relatives proved unsatisfactory, but after many operations, extending over a year, autogenous grafts finally covered the entire area. In all, over two hundred segments were removed

Fig. 15.—Total avulsion of scalp, including right eyebrow. The scars over ears are due to removal of hair-covered parts to form new eyebrows.

from her thighs and arms (Thiersch method) before healing occurred. In this instance an effort was made about every six weeks to cover an area approximately 4 inches square on opposite sides of the scalp, and

when she recovered from the anesthetic protection was afforded by a wire cage, so that the grafts were exposed to the air. For a long time the grafted area cracked and ulcerated from slight pressure, but eventually a movable thin scalp resulted, and the defect is very well covered by a wig with a very low "bang" to cover the eyebrow region. Four unsuccessful later efforts were made to graft an eyebrow, hairy parts being taken from her adjacent scalp and pubes, and on the other occasions from the scalp of donors.

Avulsions of a limb from the socket (*disarticulations*) are commonest at the shoulder and knee, and often the separation is done with almost surgical precision. The vessels are usually so twisted or stretched that little bleeding occurs. In a recent case the patient had his right elbow caught in a belt-conveyor, and was brought to the hospital with the intact humerus entirely denuded from a point just below the axilla, and an immediate operative disarticulation of the shoulder was done. There was practically no bleeding despite the tearing away of the limb at the elbow and the stripping of soft parts from the armpit down. The remaining muscle and skin was sufficient to form a good flap, and healing was almost as prompt as if the disarticulation had been performed deliberately.

Treatment of this class of cases designs to control shock and bleeding and to disinfect by iodin, later making such closure as the conditions warrant. Extensive manipulation should be postponed in the presence of shock.

BULLET WOUNDS

These are exceedingly common in civil practice, and they generally occur from revolvers (.32, .38, and .44 caliber), shot-guns, and rifles.

Symptoms.—The wound of entrance is ordinarily round, with dark edges, and if the contact is close, powder stains are generally in evidence. Occasionally clothing has been ignited, and then burns of various degrees are added factors. In some instances the wadding of the missile or pieces of clothing are carried subcutaneously. If the head or thorax has been struck, it is not uncommon for the bullet to glance and travel a long distance subcutaneously after striking the bone just beneath the place of entrance. Many such cases soon show a ridge of swelling and ecchymosis outlining the course of the bullet. Bleeding is usually slight unless a main vessel has been cut, and then the blood is more likely to collect subcutaneously than to appear at the wound of entrance or exit. If the wound is over a reasonably large vessel, such a hematoma may within a short time develop the hum or thrill characteristic of an arteriovenous aneurysm. I recently had

such an occurrence in the femoral vessels following the wound of a .38 caliber bullet that entered the upper part of the thigh, traversed the limb, and appeared in the buttock subcutaneously. In this patient a large hematoma obscured the actual conditions for a few days.

Treatment.—The wound is sterilized by flooding it with iodin and then applying a sterile moist dressing after a small rubber drain has been inserted.

Probing is exceedingly dangerous and should never be done. Tetanus antitoxin is to be given in every instance. If the bullet is doing harm, it will manifest itself by adequate and appropriate signs of pressure, and it can be removed when the chances of infection have subsided. In many instances it is suitably encysted and may be left undisturbed indefinitely. If the missile is hidden, careful radiographic examination is the best guide to the location, but in such cases the *x*-ray plates must be made in at least two axes, and preferably stereoscopic. If doubt exists as to the presence of wadding, clothing, or other foreign substances, the wound is to be enlarged and inspected; this is especially needed in Fourth-of-July wounds from "blank cartridges."

Bullets penetrating the **thoracic cavity** are never searched for at once unless evidences of heart injury exist.

If the **abdominal cavity,** however, has been penetrated, immediate operation is necessary to determine the presence or absence of intra-abdominal mischief, as in such cases it is unwise to await definite evidences of hemorrhage or peritonitis.

Skull penetration requires operation, as a rule, because of the possibility of hemorrhage or infection from the bullet, other foreign bodies, or spiculæ of bone; however, it is usually safe to wait some days in such cases, and in all instances *x*-ray localization is essential.

The surgeon in every case must be certain that the bullet has actually entered the suspected cavity and not ricocheted into a more or less subcutaneous locality.

Hematoma formation may eventuate in abscess, and in such an event the bullet, or some foreign substance entering with it, will be usually found in the cavity thereof.

Joint penetration by a bullet demands expectant treatment with suitable drainage, extension, and immobilization, on the theory that infection will be quite likely to subside or localize unless stimulated by manipulation that often is like a search in the dark. Joints are less likely to become infected if a 2 per cent. formalin solution in glycerin is injected at once, the part being kept in forced extension.

As a matter of practice, it may be stated that an intra-abdominal

bullet wound is the only variety requiring *immediate* exploration; all the others can usually await the development of symptoms and proper localization.

Bullets affecting bones practically cause symptoms of compound fracture, and they are treated accordingly. If the bone is bored through with little or no comminution, the treatment resolves itself into sterilization and drainage. Bullets embedded in bone usually do no harm and are left alone.

Shot-guns cause more or less "peppering" of the parts with buckshot, and often many powder grains are embedded. Penetration is usually relatively superficial, otherwise the parts present symptoms not unlike extensive lacerating or crushing injuries. Shot is picked out after the area is iodinized; powder grains are likewise treated, and their removal is facilitated often by brisk scrubbing of the part. It is stated that a dressing of hydrogen peroxid favors the removal of powder grains, but personally I believe that repeated poultices of sterile oil or vaselin better softens the tissues; at best the extraction is a tedious and painful process. Zinc oxid adhesive sometimes sweats out powder flakes.

STAB WOUNDS

Generally these are from knives, stilettos, and other pointed objects like spikes, splinters, umbrellas, canes, and tongs.

The **signs** are those of lacerated wounds, and the treatment is based on control of shock, hemorrhage, and infection. Sterilization and drainage are the two essentials, but meddlesome interference is likely to prove harmful, especially if pursued with the idea of "opening up" the zone penetrated. *Intra-abdominal* stabs demand immediate exploration, even though the wound seems to have involved only the omentum or mesentery that so often is found extruding. So far as possible, operative access to the abdomen is gained close to the median line, and the incision is planned so that it may be extended if required. The retrorectus line of approach is ordinarily the best, and the original stab may be used for drainage purposes.

Stabs of the **chest** may injure the intercostal vessels and cause alarming bleeding that often is hard to control. Packing ordinarily suffices, but if this fails, it may be necessary to clamp the lower edge of the rib or to encircle it with catgut passed on a wide semicircular needle or sharp ligature passer.

Mucous membrane wounds, as a rule, heal kindly, notably those of the mouth and nose. Bleeding is generally promptly controlled by pressure; failing this, an encircling ligature is often needed.

Epistaxis that is not controlled by packing the anterior naris can be checked by plugging the posterior naris with cotton passed on a Bellocq's canula; a soft-rubber catheter answers the same purpose. A very effective method is to insert a condom or rubber glove finger or cot far into the nostril and then distend it by air or water. If a cotton or gauze plug is used, it may be previously moistened in cocain or adrenalin. Such a plug rapidly becomes foul, and should not be allowed to remain more than twenty-four hours, and the removal of it may be facilitated by injection of peroxid of hydrogen, albolene, or oil.

Urethral wounds often bleed excessively, and if injections of adrenalin are inadequate, a large steel sound may be passed and allowed to remain in place several hours, thus acting as an effective plug.

Wound Complications

These may be said to consist of *infections*, *aneurysms*, *keloids*, and *contractions*.

Wound Infection

An *infected wound* is one that harbors and nurtures pyogenic organisms. The ordinary pus-producing germs are the *Staphylococci* (*aureus*, *citreus*, and *albus*) and the *Streptococci*. Other types of infection may also be caused by several organisms, but for practical purposes the two foregoing are most important. If more than one variety of bacteria is present, a *mixed infection* is said to exist, and wounds thus invaded are often serious and protracted.

This general subject is also discussed in the chapter headed Infections of the Hands, p. 62.

Causes and Varieties. Germs are more or less constantly present, and they gain entrance at the time the wound is produced (*primary infection*) or are subsequently introduced during the course of treatment (*secondary infection*); in another class the original infected focus is the source of involvement of distant or adjacent tissues (*reinfection*). The vitality of the part wounded (*local resistance*) is also a factor, as is the constitutional physique (*general resistance*).

Germs vary in their virulence and in their manifestations, and an essential prognostic element is the amount of the introduced infection and the vital resistance of the subject; in other words, the outcome is directly proportionate to the amount of the dose and the capacity to react from it.

Prophylaxis is a most important feature, and if sterilization can be promptly and thoroughly accomplished the extent of infection will be minimized.

Staphylococcus infection is the least dangerous and the most common. It is characterized by a tendency toward limitation, abscess formation, and the presence of large quantities of thick yellow or whitish pus (the so-called "laudable pus" of the older surgeons). Occasionally the pus becomes greenish, indicating *pyocyaneus* infection, often of low grade and usually of good import.

Streptococcus infection is the most dangerous but, fortunately, less common. It is characterized by a tendency to invade adjacent tissue, little if any abscess formation or pus, and is prone to involve the lymph-channels and thus gain entrance into the general circulation.

Cellulitis is inflammation of the subcutaneous cellular tissue, and if wide-spread usually means a streptococcic infection.

Lymphangitis is inflammation of the lymph-vessels.

Lymphadenitis is inflammation of the lymph-glands.

Septicemia is systemic pyogenic infection, ordinarily of streptococcic origin.

Pyemia is that form of infection due to metastatic deposits from an original pus focus.

Phlebitis is inflammation of a vein, and it often occurs as a septic thrombophlebitis.

Symptoms.—*Local signs* in the wound are the redness, pain, heat, and swelling characteristic of all inflammatory reaction. Wounds that bleed freely are less likely to become infected than those of the punctured variety.

The local onset of infection is ordinarily manifested by throbbing or stinging pain, very promptly followed by swelling, heat, and redness. If seen early, the wound discharge will be thin and watery, not unlike brownish serum; if seen later, pus will be present in varying quantities. If the process is sharply localized the infection is probably solely *staphylococcic*, but if there is little or no pus, and if the part is red, swollen, edematous, hot, and painful, then the infection is probably *streptococcic*. If there are tender red streaks running from the focus, *lymphangitis* is present and the neighboring glands will be swollen and painful, constituting *lymphadenitis*. If the area is quite red and brawny and more or less circumscribed, then *cellulitis* is present.

General signs are malaise, loss of appetite, fever, chilliness, and, in advanced cases, chills, high fever, and sweats. These constitutional signs depend upon the type and extent of the infection and the vital resistance to it. If these signs persist, *septicemia* is present, and we speak of the condition also as "sepsis," "bacteremia," or "septic state."

If pus foci have been carried from the original zone or from a broken-down thrombus to more or less distant parts that show evidences of abscess formation, then *pyemia* exists. Between the chills and high fever of pyemia the temperature may be normal or subnormal, and each chill is said to represent the formation of a metastatic abscess. Such abscesses may give more or less appropriate evidences if they form externally, but if they are deep seated their location may be most difficult to determine. Involvement of the lung, liver, spleen, and kidney is very common in this condition.

In all these "septic states" the examination of the blood is of much diagnostic, therapeutic, and prognostic value.

Differential diagnosis as between various forms of wound infection is not particularly important except in so far that the surgeon must be reasonably sure whether or not a pus focus is within reach of surgical attack; in other words, the type of treatment depends in large degree upon the possibility of incising and draining pus-containing foci.

In joint infections, *rheumatism* (simple or gonorrheal) is sometimes diagnosticated when the history or local signs of injury are imperfect or indistinct; such an error is usually avoidable by careful repeated observations, especially if a blood examination is made. The newer teaching of some would have us believe that "rheumatism" is an infective process probably of streptococcus origin, but even with this in mind the error should not be made of overlooking a contiguous or distant abscess.

Typhoid, *pulmonary tuberculosis*, and *malaria* sometimes cause confusion because the temperature-curve in each may for a time resemble that of a wound infection. Here, again, careful examination plus blood tests provide the earliest and safest differentiation. *Erysipelas* is easily confused with *cellulitis;* the newer views regard them as practically identical, and hence their separation is more academic than necessary.

Treatment.—*Prophylaxis is the main element, and, as stated hitherto, every wound not made with surgical intent under aseptic conditions should be regarded and treated as if already infected.*

This means that the primary treatment by sterilization, suture, and drainage should anticipate infection and thus be appropriate to the end in view. Iodin disinfection is the best single means at hand, and this antiseptic should be used liberally and fearlessly, as it may be applied to any broken surface or member with impunity, the eye and other delicate parts being included (Fig. 16).

Suturing should not be too tight.

Drainage must be adequate, and not so placed that it will act as a cork or dam; for this reason rubber acts better than gauze drainage.

Probing is mentioned only to be condemned, as in many instances the probe acts as effectively as a hypodermic needle in inoculating parts not already infected.

Moist dressings of salt, boric, alcohol, or some equally mild solution should be used; strong antiseptics lower the local resistance and further burden tissues already sufficiently damaged.

Curative measures for the various wound infections may be said to be (*a*) *general* and (*b*) *local*.

(*a*) *General Measures.—Food*, *sleep*, and *fresh air* are the essentials, and each should be provided in large doses.

Food should be furnished often and in small amounts, rather than less often in large amounts. It should be concentrated and fluid, consisting largely of meat-soups, broths, milk, eggs, and a reasonable amount of whisky or beer to those accustomed to using such beverages. Water must be taken freely, and if necessary it can be given by rectum in the form of a "drip" for several hours continuously, or 6 ounces may be given every four hours or oftener. Ordinary tap-water acts just as well rectally as salt solution, and apparently causes less thirst and kidney irritation. Whisky may or may not be combined, according to need. Rectal feeding should be postponed as long as possible because few patients are long tolerant to it.

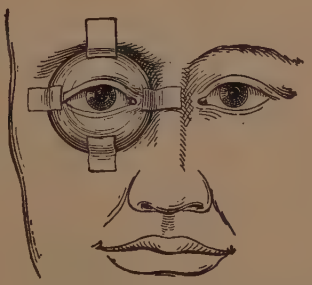


Fig. 16.—Watch crystal protector and adhesive to prevent escape of purulent secretion from one eye to another, or from a forehead wound to the eye.

Sleep will be better if the patient is kept as quiet as possible, especially if the fresh-air treatment can be combined. Sponging, hot drinks, body massage, and like measures are sometimes effective. If drugs are needed, trional, veronal, medinal, and the bromids act best. Morphin must be very cautiously used.

Fresh air and *sunshine* will act well in nearly all cases, especially if tolerance is gained by giving the patient longer séances daily, and eventually many cases are left out of doors nearly the entire time. In many instances exposure of the wound to the air and sun is very effective, especially in the sepsis from burns or extensive denudation;

here also the patient should be rendered tolerant by daily increasing periods of exposure.

(*b*) *Local Measures.*—These aim to prevent the spread of infection focally or distally, and the means at hand consist generally of:

(1) External applications.

(2) Incision and drainage.

(3) Sera and vaccines.

(4) Sedatives.

(1) *External Applications.*—In the early stages of infection, and before fluctuation or other local signs of pus are present, the external use of various substances may prove of aid in (*a*) preventing the spread of infection, or (*b*) focalizing the effects of same.

These applications usually take the form of *moist dressings*, and these are generally used *hot* at first and later are *cold*. Numerous solutions have been employed, but the essential feature is probably the moisture rather than any inherent virtue of the antiseptic employed. Caution must be observed in the use of any antiseptic that might have any harmful local or general effect if absorbed, and for that reason carbolic, bichlorid, and drugs of this class are less generally used than formerly.

Salt, boric, and aluminum acetate solutions are very generally used, and they are quite harmless even to denuded surfaces or when long employed. Several layers of gauze should be applied, and in an extremity it is essential not to encircle the part until it has been sufficiently protected by many such layers, so that the circulation will not suffer by pressure. A very convenient method of applying such a "wet dressing" is to soak a sterile bandage in the solution and then unreel it in criss-cross layers over the part, and in this manner the same effect is gained as if many layers of compresses had been used. Oiled silk or rubber tissue (or some substitute for the latter) covers the dressing, but holes should be cut in the protective so that no poultice or cupping action occurs. The gauze is kept moist by allowing the solution to reach it through a glass tube shoved between the meshes, and usually this will be required once each four or six hours. The part should be elevated, and if a joint is involved, the support and extension from a splint or apparatus is necessary for comfort and to prevent contractures.

My experience is that hot moist dressings are most useful in the early stages of infection, and thereafter cold applications are of greatest worth. The use of a 25 or 50 per cent. alcohol dressing relieves pain and frequently proves of value. If a moist dressing is used in the presence

of a wound especial care is then necessary so that the drug may have no harmful local or general effect; for that reason carbolic or mercurial solutions are often dangerous. I once saw a child whose face was horribly deformed by cancrum oris developed from the continuous use of weak bichlorid lotion following a simple infected abrasion of the cheek.

If there is much odor from the wound it can be controlled by the use of a permanganate of potash solution of a deep pink color. Equally effective is a solution of 1 dram of iodin to a pint of water, and either of these makes an excellent irrigating medium. Magnesium sulphate in saturated watery solution (or less strong) seems to act especially well in erysipeloid infections.

Continuous bath or *immersion* treatment has not been especially useful in my experience; at best it cannot be used for more than a short time because it causes maceration of the parts. It is employed practically only for the hands and feet.

Bier's cups and *bands* for hyperemia are sometimes useful adjuncts, especially in the early and late stages.

Local injections about the periphery of the infection were once largely used in erysipelas infections, but the method is now rarely employed.

Baking and other forms of *dry heat* are rarely used now in the acute stages.

(2) *Incision and Drainage.*—The indications for these are (*a*) the presence of pus and (*b*) spreading edema and brawniness.

Pus makes its presence manifest (aside from systemic signs) by *fluctuation*, *localized pain*, or distinct circumscribed *induration*, and the presence of any two of these justifies exploration.

Throbbing pain, spasm of muscle, and **pain on motion,** if localized, are three further symptoms found more or less frequently in conjunction with the trinity of cardinal signs previously mentioned (Fig. 17).

Incision is to be made over the place of maximum fluctuation, pain, or induration, and in *direction* should parallel the underlying vessels, tendons, and muscles unless there is good reason to vary this fundamental rule. The *length* and *depth* of the cut should be adequate in the first instance, so that it may not require repetition. The pus may often be first located by hypodermic puncture, otherwise the skin and subcutaneous parts are alone incised by a small opening, and through this a closed artery clamp is then thrust as deeply as desired, and then it is withdrawn with the blades open. The incision is then enlarged, or reinforced or connected by others, so that the pus focus may be adequately exposed for drainage (Fig. 18).

In other cases, with or without the definite finding of a pus focus, it rather rarely may be necessary to make one or more incisions to

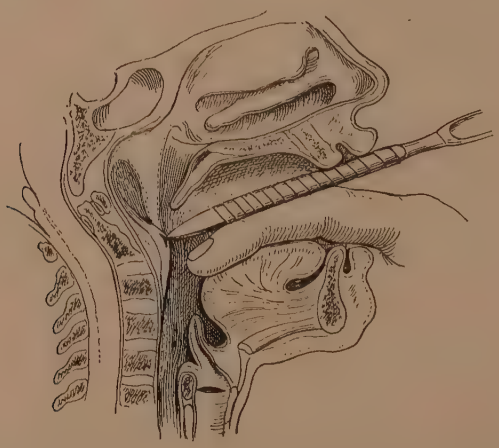


Fig. 17.—Incising retropharyngeal abscess with a cotton-covered scalpel.

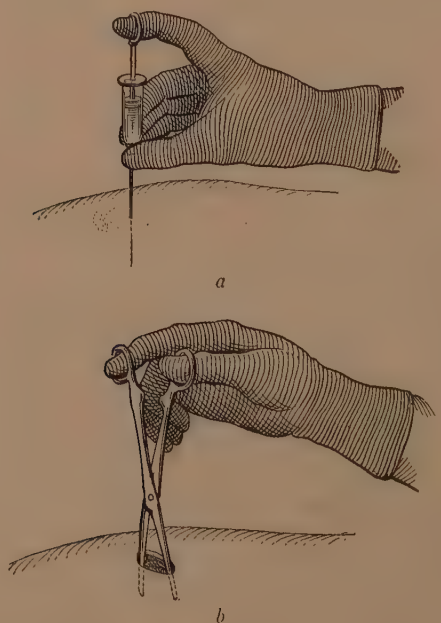


Fig. 18.—Method of opening a deep-seated abscess: *a*, Locating the pus focus by an aspirating syringe; *b*, enlarging the incision by widely opened pointed scissors or artery clamps.

relieve tension in a swollen and more or less edematous area. In such cases the rule is to incise to the depth of the fascial layer only,

placing each of the incisions so that they may intercommunicate through the medium of drainage (Figs. 19–21).

Less often incisions are made so that drainage may be "through and through," and then the drain is passed between tendons and vessels so that no structural damage is done.

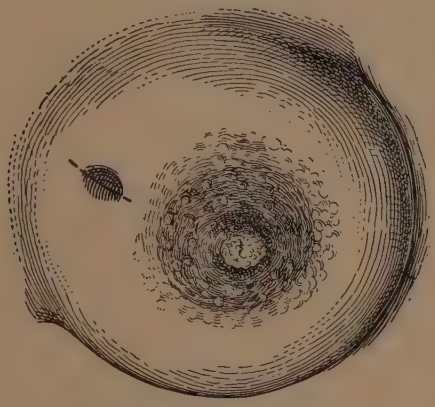


Fig. 19.—Abscess of breast and proper line of incision radiating as a spoke of a wheel, with the nipple as the center.

Drainage material is generally gauze or rubber.

Gauze drainage has the disadvantage of adhering to the edges of the wound, and it also soon becomes saturated with the discharge, and will then act as a plug or cork and defeat its purpose.

Fig. 20.—Sites of pus in abscess of breast: *a*, Subcutaneous, or extraglandular; *b*, glandular, or extramural; *c*, muscular, or mural.

When a walled-off or circumscribed pus cavity has been emptied of its contents, then packing it with gauze is of great value to encourage granulations. If there is much oozing of blood, gauze drainage may also be used.

Gauze absorbs better when moist, and it sticks less when previously soaked in sterile olive oil, albolene, or vaselin; hence drains are fre-

quently soaked in salt, boric, or alcohol solution or moistened by some oily substance. When healing is to be promoted and when drainage is rather slight, gauze soaked in 10 per cent. balsam of Peru (in castor oil or glycerin) is a splendid application. "Medicated" gauze (iodoform, carbolic, and others) is not much used.

Rubber drainage is by tubes or tissue. The former must not be used over a long period because they cause a pressure-necrosis and thus tend to form sinuses or erosions, leading to ulceration or hemorrhage. The tubes should be fenestrated or split lengthwise. If desired, a wick of gauze may be passed through the tube, thus forming the so-called "cigarette drain."

Rubber-tissue drains are very largely used because they are soft and readily fashioned into appropriate size. If they are folded like an "accordion pleat" more channels for drainage will be provided than if

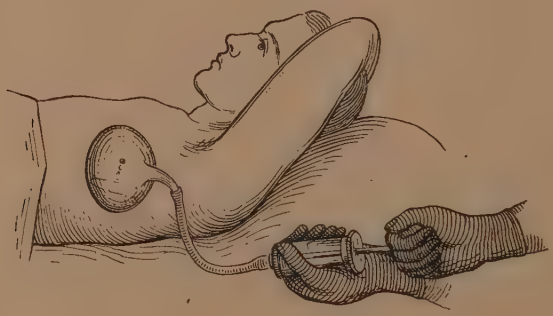


Fig. 21.—Aspirating cup following incision for breast abscess.

each layer is folded in the same direction. The typical "cigarette drain" is made by enclosing a rolled section of gauze in a piece of tissue. This tissue (known also as gutta-percha tissue) is sold in yard-square or larger lots, and is sterilized by soaking desired sections in 1 : 5000 bichlorid for forty-eight hours. Then each section is dried between sterile towels and rolled into a loose coil surrounded by sterile gauze or placed in a sterile jar for use as desired. It may also be kept in alcohol or a weak solution of bichlorid.

Rubber bands, such as stationers supply, make excellent drains, and personally I prefer them because they can be boiled as required. A discarded rubber glove furnishes good drainage material also.

Whatever material is used, it should act as a *drain* and not as a *plug*, *dam*, or *cork*. It is better to use two or more small drains than one large drain.

(3) *Sera and Vaccines.*—These have not proved very effective, and,

personally, I have never derived any special good from them. Apparently the so-called "mixed bacterins" are likely to do most good, as many wounds show some mixed infection by staphylococci and streptococci.

Autogenous vaccines are the best, but it is difficult to prepare them and they are of limited availability, and thus "stock" vaccines are used generally.

Antitetanic serum is of distinct value from a prophylactic standpoint, and it should be used whenever a wound has been contaminated by the soil, street dirt or stable refuse, and in all bullet and Fourth-of-July wounds.

(4) *Sedatives.*—Anodynes and hypnotics are to be used judiciously, and no morphin should be given unless absolutely needed. Codein in ½-grain doses is excellent for pain, but it is to be remembered that continued pain means pressure, and pressure means inflammation, and inflammation often means that the focus has not been reached, and hence anodynes must be replaced by the knife and drainage.

Trional and veronal (alone or in combination) and the bromids are the hypnotics of greatest value.

ANEURYSMS

These are very rare complications of wounds, and their occurrence is limited practically to stab, bullet, and other perforated wounds. They occur most commonly in the thigh, upper leg, arm, and face.

These traumatic forms of aneurysm are the so-called "false" and the "arteriovenous" aneurysm.

False aneurysm occurs when the coat of an artery has been cut and the blood leaks out and is retained in a fluid state by a fibrous wall or sac that forms about it, the vessel walls themselves forming no part of this aneurysmal sac.

Arteriovenous aneurysm is an abnormal connection between an artery and a vein. Bullet wounds are the commonest source of origin.

Treatment is the same as for any other similar condition. (See also pp. 606–609.)

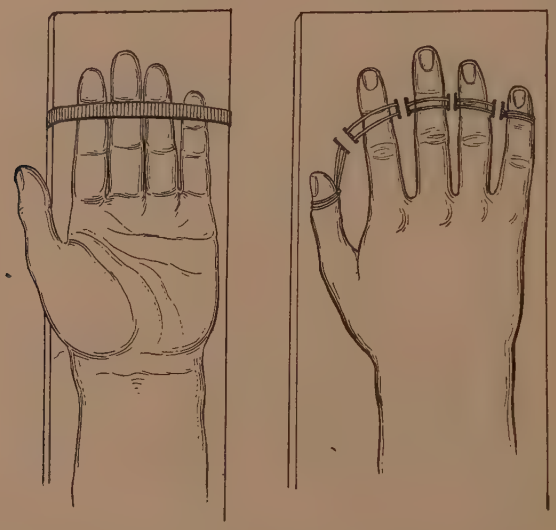
KELOIDS

These are redundant or hypertrophied scars that often form ugly raised ridges along the line of the original wound. Some persons are particularly prone to them, notably negroes. No known source of origin has been ascertained. They seem most likely to follow wounds about the face and neck, especially if the wound originally was infected or not well coapted.

Treatment.—Many spontaneously subside and others are benefited by *x*-ray, high-frequency, and radium applications. Formerly the injection of thiosinamin was in vogue, but of late it is not much employed. Operative removal is rarely successful, as the second wound is quite likely to also become keloidal.

CONTRACTURES

Wounds that cross joints often leave scars that more or less contract soft parts and thus interfere with free motion, flexion being more usual than extension contraction. Infected wounds and burns are frequent



a *b*

Fig. 22.—Rubber-band exerciser for stiff fingers: *a*, Arranged to exercise flexors by passing rubber band around a splint; *b*, arranged to exercise individual extensors by passing rubber band through slits in a splint. Various modifications suggest themselves for exercising special fingers or the wrist or forearm.

sources of origin, and the hands, face, and neck are most often involved; of the larger joints, the elbow and knee frequently suffer.

Treatment.—Any wound at or near a joint should be regarded as a presumptive contracture-producer, and the early treatment should be planned to guard against this sequel by adequate splintage, posture, and early motion. In the hand and upper extremity the tendency will be for *flexure* contraction, and hence the splintage should be on the *posterior* surface. In the foot and lower extremity the opposite tendency pertains, and hence splintage should be on the *anterior* surface.

In threatened finger contractions I have often found it of value to

fashion a thin board the width of the spread-apart fingers and bind it to the back of the hand and above the wrist, sometimes making the lower end of it notched or slit to fit each finger-tip. To each notch or through the slits is fastened a rubber band, and this is put over the finger-tip, and thus a continuous elastic pull is provided that quite effectively limbers up a stiff digit (Fig. 22). The same idea can be applied in the treatment of other stiff joints from this or other sources.

If the contracture exists and cannot be overcome by *gradual* bending, then some plastic operation will be necessary. This may consist of skin-grafting, either by an autogenous skin-flap or Thiersch grafts.

ULCERS

These are indolent, granulating, infected areas involving the skin or deeper parts. They are very common, more so in men than women, and are generally found in persons over forty-eight; that is, at the arteriosclerotic age and at a time when vascular and circulatory changes are likely to appear.

Causes.—These may be said to include three general factors:

- I. Injury.....
  - Wounds—incised or contused when infected.
  - Thermal.
    - Burns.
    - Frost-bites.
  - Chemical.
    - Acids.
    - Caustics.
  - Electric.
    - Electric contact.
    - *X*-ray.
- II. Inflammation.
  - Fevers (like typhoid).
  - Varicose veins and phlebitis.
  - Cellulitis, erysipelas.
  - Infections.
- III. Diseases.....
  - Syphilis, tuberculosis.
  - Cardiovascular—nephritis.
  - Diabetes, gout, rheumatism.
  - Tropical.
  - Nervous.
    - Tabes.
    - Syringomyelia.
  - Malignant.
    - Cancer
    - Sarcoma.

From the standpoint of injury, the usual origin is from a neglected or poorly treated small break in the skin in a person having poorly vascularized tissues due to varicose veins or perhaps arteriosclerosis; or in those having some constitutional disease like syphilis, diabetes, nephritis, rheumatism, or tuberculosis.

The inner border of the middle and lower third of the leg is usually the place of election, as this provides a location normally poorly supplied with soft parts, and, in addition, a site likely to be the seat of venous stasis from gravity or posture. Many cases, however, especially in women, appear to come on spontaneously, even though the tendency is always to ascribe the condition to a blow, however trivial or remote it may be.

What follows refers especially to **ulcer cruris,** or leg ulcer.

Symptoms.—These depend in part on the origin of the process. It has been said that ulcers of the upper part of a leg are generally syphilitic, wholly or in part, and that those on the lower half are varicose, wholly or in part.

Very few of the cases are seen by the physician from the onset, and the patient usually comes with the history of a "barked shin" or a small wound or excavation that would not heal despite home remedies of the "carbolic salve" and allied class. Soon the sore "festered," became red and angry, and was a source of annoyance, pain, or apprehension.

At this stage the *recent* cases will usually exhibit a more or less sharply localized reddish area of superficial infection with a break in the skin as the focus. The central part of this area is likely to be deeper than the margins, and is prone to be covered by a viscid pus that may be odorous. Varicose veins may be prominent, or only a few venules may be seen. There may be some enlargement of the glands of the groin.

If seen a *little later* (say after a week or ten days from the supposed onset) the above manifestations may be similar, but ordinarily the pus discharge has created a dermatitis or eczematous area, so that from an initial small site of injury a reddened surface of large extent may exist, causing duskiness, swelling, itching, burning, or pain; in other words, there is a subacute infected wound surrounded by an area of eczema.

The foregoing applies to the *acute ulcerations*, or those that come on within a few weeks of the causative incident.

After the above period, cases then are of the *subacute* and *chronic* variety, and a patient seen then will ordinarily show a more or less circular or punched-out ulceration with a stenciled margin of dusky red or livid blue skin, surrounded by a surface of dry or moist eczema of varying size. The margins of such an ulcer may be sharply or illy defined, indurated or soft, excavated or perpendicular. The central portion of the ulcer will be grayish and covered by a more or less

tenacious pus and some bleeding may occur when the surface is wiped, especially if there are occasional tufts of granulations. Formerly the appearance of the margin of an ulcer was thought to be of diagnostic importance, but there are few cases in which this sign is wholly determinative. Punched-out, well-defined, indurated, undermined bilateral ulcers, especially in the upper half of the leg, are likely to be syphilitic.

Generally speaking, there are two types of cases—namely, the **moist** and the **dry.** The former often constitutes the recent variety occurring in persons under forty-five; the dry form generally indicates age in the possessor and in the condition itself. In persons whose tissues are denuded of moisture the condition resembles often a vaccination-like area surrounded by dry, cracked, and parchment-like skin.

In the *recurrent* type, scars of former ulcers will be visible either as whitish puckerings or as the brownish, coppery cicatrices so typical of luetic origin. Many recurrences are primarily due to a latent or uncured periostitis or osteitis, and the ulcer is but an effort to relieve pressure and allow escape of pent-up secretion.

In the syphilitic, this recurrent type is quite likely, especially if antiluetic treatment has been inadequately undertaken. Such ulcers are usually gummatous manifestations. In this connection, it is well to remember that an ulcerous wound in any part of the body may resist energetic treatment until an antisyphilitic regimen is instituted.

Many ulcers remain healed for varying periods, and then break down with little or no provocation, and subsequently heal, only to again reform.

Treatment.—This may be described as *local* and *general.*

Local Measures.—The indications are to (1) prevent the spread of the ulcer and its secretions; (2) stimulate granulations; (3) limit undue scarring and prevent recurrences.

The foregoing can be met by a form of treatment that aims to (*a*) cleanse; (*b*) stimulate; (*c*) support.

(*a*) *Cleansing* designs to convert an unhealthy, pus-discharging surface into a healthy, granulating area. The pus is washed off by salt solution or bichlorid (1 : 2500) or iodin water (iodin 1 dram to a pint of water). If the foregoing are inefficient, pure peroxid applied on cotton and allowed to soak through the tenacious pus will answer.

(*b*) *Stimulation* will be necessary if the foregoing does not bring a healthy glow to the ulcer, and this may be done either by mechanical or chemical means. Rubbing with gauze, or scraping the surface with

scissors, scalpel, or curet are examples of the mechanical means of irritating the gray granulations. Snipping with scissors may be needed. Chemical irritants, such as pure carbolic or strong silver nitrate solutions, can be applied over the surface to produce a cauterant effect. Whatever means are chosen, in large ulcers care must be used not to attempt to stimulate more than one-half the surface at the first dressing until the reactive power of the patient is ascertained.

If granulations are not grayish but fairly healthy, then the use of gauze soaked in balsam of Peru or tar (10 per cent. in castor oil) is an excellent application, especially as it will not adhere to the parts. If there is an area of eczema surrounding, this should be coated with zinc oxid ointment. Sometimes a first dressing of bichlorid (1 : 5000) on gauze softens the area and permits of other treatment later more effectively. If there is not much discharge, the use of scarlet red salve up to 10 per cent. strength I have found satisfactory. In my experience it is irritating to secreting surfaces and on any area if used more than two or three times consecutively. It should be applied to the raw area only about $\frac{1}{8}$-inch thick. If the discharge is exceedingly scanty, the margins of the ulcer can sometimes be quickly coapted by strapping with $\frac{1}{2}$-inch sections of adhesive plaster, care being taken to so overlap these that secretions may escape. Such straps should not encircle the limb enough to interfere with circulation. If there is much odor, gauze wet in permanganate of potash (in a good pink strength) or iodin water (1 dram to a pint) for a few dressings will usually suffice. Carbolic should never be used except as a caustic, as indicated.

(*c*) *Support.*—Whatever the medicament may be, it should be applied to the ulcer on a folded gauze compress, with a layer of cotton on the latter if necessary, all to be held in place by a snug roller bandage that is applied from below the ankle to below the knee. The limb should be elevated during this application and enough adhesive plaster or pins used to prevent slipping.

In *chronic* cases, or where recurrence is being guarded against, the use of some sort of stocking may be necessary. These are costly, they soon smell and stretch and become useless. To provide an effective, cheap, and washable supporter I advise a linen mesh bandage, such as dealers now supply in 5-yard lengths of varying widths. Such a bandage costs 40 cents, and while one is being worn the other is in the wash. In the trade they call these "Ideal" or "Green Cross" bandages. A patient soon learns to apply a bandage like this so that it will not slip, and it is quite as effective as a stocking. Along this

same line of "support" treatment it is an excellent plan to enjoin the patient to keep the limb elevated whenever opportunity presents. With this in mind, the foot of the bed can be elevated on a few bricks or other support, so that by changed gravity some of the pressure may be removed from overdistended vessels.

Very few of these cases will take time enough away from work for operative treatment designed to remove varicose veins or excise ulcerous areas or for skin-grafting. Operations of this kind are certainly curative in many instances.

General Measures.—Here the aim is to remove constitutional causes, if possible, and to correct vicious habits and methods of living.

Search should be made for any cardiovascular-nephritic combination, and also for alcoholism, diabetes, syphilis, gout, rheumatism, and tuberculosis. Oral sepsis (teeth, tonsils, gums) must not be forgotten as a potential source of pus in this and in other forms of protracted or recurrent infection. If any of these are found, suitable treatment should be instituted.

In the average case the use of the following has been found effective, as it meets the very common unity of rheumatism and arteriosclerosis:

℞. Potass. iodid..... gr. v;
Vin. colch. rad..... ♏xv;
Syr. sarsarp. co.....q. s. ℥j.—M.
Sig.—One dram three or four times daily.

ERYSIPELAS

This acute infective disease of the skin and mucous membranes is now known to be due to streptococci that gain entrance through some more or less demonstrable break in the skin or mucous surfaces. For a long time it was regarded as being due to an independent organism, and because of its contagiousness patients were isolated. Some authorities assert that it may be induced by staphylococci and other bacteria, but the accepted source of origin is the *Streptococcus erysipelatus* (cultivated by Fehleisen in 1883), which is probably identical with the ordinary *Streptococcus pyogenes.*

Causes and Frequency.—Formerly the "idiopathic" or medical form that so commonly affected the face was supposed to be of unknown origin, and the other, "traumatic" form, was traced to a demonstrable wound in the skin or mucous membrane.

At present the belief is that it is always due to some break in the external texture, and that the facial forms commonly arise from a

nasopharyngeal infection due to erosions, abrasions, or other lesions. Practically speaking, nine-tenths of all the cases affect the face, and the remainder the leg and foot equally often. Puerperal infection was at one time regarded as occurring from erysipelas, but now it is known to be usually streptococcic.

There is an individual predilection to the affection, as in many persons it often appears recurrently in association with trivial wounds or even with nasopharyngeal "catarrh"; such persons are probably so-called "germ carriers." It quite commonly occurs about ulcer of the leg, and scalp invasion is not infrequent from pediculi and other irritants.

Pathologically, it is a progressive lymphangitis, and if it spreads deeply, necrosis occurs, resulting in so-called *Phlegmonous* or *gangrenous erysipelas*.

Metastases may be carried in the blood-stream to the lung, liver, spleen, heart, and other organs.

Symptoms.—An incubation period of from fifteen to sixty hours precedes the typical onset with a *chill*, soon followed by fever, which may reach 105° F. in the first twelve hours, and which tends to remain high, but which is remittent in type. There may be nausea and vomiting, with malaise and prostration. The pulse is elevated. Mentally the patient is generally active, and delirium is not uncommon in the first few days.

During this early period there may be no local signs in the wound or other focus, but after the first day burning and tension may be complained of, and then the invaded region is seen to be edematous, red, and swollen, the margins of this sharp-edged area being wavy and irregularly zigzag, often compared to the outline of a burned piece of paper or the edges of burning grass. The originating focus is often less actively inflamed than the parts distal to it. The neighboring glands are swollen, tender, and hard. The swollen area is firm, tense, and rather resistant, and when the finger is removed from it a yellowish-white place remains. Blebs, blisters, and spots of gangrene occur in severe cases, and serum or pus may exude from these, to be later replaced by a brownish scab or crust. If pus has been present in the original wound, it becomes seropurulent or serous. When new areas are invaded the local signs are more prominent than in the regions previously affected.

While the spread of the process is usually more or less direct from the original focus, it is not uncommon to have it appear some distance away, leaving the intervening area free.

After several days the temperature begins to remit, but as new areas develop it again ascends, and if the attack has been severe much systemic prostration occurs. The skin peels at the end of the disease.

The **average duration** is fourteen days in persons under forty, but it lasts longer after this period of life (Anders).

Relapses are said to occur in about 10 per cent. of cases, and these often are due to self-inoculation from scratching, the clothing, bedding, or dressings.

Prognosis is excellent, and the average mortality is 6.5 per cent., the extremes being 3 per cent. in young adults and 45 per cent. in those over seventy, with a mortality in wound infection of 14.5 per cent. (Anders). Alcoholics are bad risks, as they often develop delirium tremens.

Complications are most likely in connection with *phlegmonous* and other severe forms that may cause local gangrene or necrosis, with extensive burrowing of pus and much systemic poisoning.

Facial forms (commonly known in the hospitals as "Facial E." or "F. E.") may sometimes lead to meningitis by direct spread through the orifices at the base of the skull, or by the venous channels as a thrombophlebitis. Following operations on the head it is not uncommon to have "Facial E" appear within the first week in a wound that up to that time appeared healthy; it is especially frequent after scalp wounds, mastoid operations, and fracture of the nose. Most of these cases get well.

Pneumonia, nephritis, endocarditis, and other evidences of systemic invasion may also complicate.

Treatment.—*General measures* conserve the patient's strength and vitality, having particular regard to diet, fresh air, the use of alcohol in those accustomed to it, and such anodynes as may be required for pain. The kidneys are to be kept active by the free use of water by mouth and also by rectum if occasion requires.

It is probably wisest to isolate the patient; but, in reality, there is no more reason for so doing than in ordinary cellulitis.

Local measures have been recommended almost without number, and cure is often ascribed to them with about as much basis as if they had been similarly used to "hasten the desquamation" of scarlet fever, measles, or any other disease of self-limited type.

Wounds should receive the maximum initial and subsequent care, and if burrowing or pocketed pus is located, incision and drainage should be prompt.

There are, practically speaking, only two forms of local treatment in general use, namely, **wet dressings** and **ointments.**

WET DRESSINGS consist of many layers of gauze (made like a mask in facial cases) soaked in watery solutions of *salt*, *aluminum acetate* (4 per cent.), *boric acid* (saturated), *permanganate* (pink color), *iodin* (1 dram to a pint), *magnesium sulphate* (saturated or less), *alcohol* (10 to 25 per cent.), *bichlorid* (1 : 5000), or *carbolic* (1 to 2 per cent.).

Bichlorid and carbolic are dangerous, and salt or magnesium solutions act just as well. The gauze may be covered by perforated rubber tissue or oiled silk.

OINTMENTS are applied direct to the uncovered parts, or gauze may be used for that purpose.

Lanolin and *carbolic* (1 per cent.), *zinc oxid* (10 per cent.), *boric acid* (10 per cent.), and *ichthyol* (10 to 50 per cent.) are probably most often employed.

My personal preference is for a cold wet dressing of magnesium sulphate in the early stages, followed by ichthyol ointment (25 per cent.) in the later periods. If the patient is uncontrollable, and where nurses are unavailable, the ointment is used throughout.

Blebs are opened by a sterile needle only if they are purulent or very large, and scabs are never removed unless they harbor pus.

I have never seen any marked good from the injection of carbolic, silver salts, or other agents into or at the margin of the inflamed area. Serum treatment has likewise not proved of value.

ERYSIPELOID

This is a dermatitis due to inoculation of the skin by decomposing animal matter, fish, or cheese. Crab and lobster bites are the commonest sources of origin, and the hand is usually the part involved.

It is apparently to erysipelas what German measles is to true measles and scarlatina to true scarlet fever.

Rosenbach first described it, and Gilchrist believes it to be due to a ferment, as he has been unable to determine the presence of any organism.

Symptoms are externally like erysipelas, except that no blebs or pustules appear unless reinfection occurs. There are few systemic signs except pain, and there is no rise of temperature or pulse.

Treatment consists in the use of salicylic acid plaster (25 per cent.) for three days and thereafter some simple ointment. The other external measures used in erysipelas have also been advised.

TETANUS (LOCKJAW)

We are chiefly indebted to Nicolaier and Kitasato for our knowledge of the specific agent—the *Bacillus tetani*. It has been definitely determined that the germ does not grow in the presence of oxygen (anaërobic), and that it has a normal habitat in the soil and long resists the action of heat and other agencies capable of destroying the ordinary pyogenic organisms. It is not a pus producer or infective agent, and it causes very little reaction at the place of entrance, this focus usually being a demonstrable break in the skin or mucous membrane.

Wounds of the hands, feet, and face are the usual portals of entry, and penetrating, punctured, and other wounds that do not gape or bleed are the most likely to become infected, although compound fractures and crushing wounds are other predisposing sources.

The germs are found only at the site of the wound, and the systemic symptoms are due to toxins known respectively as tetanospasmin and tetanolysin; the former produces the convulsions and the latter destroys the red blood-corpuscles. In many respects it resembles an alkaloidal poison. It has been shown that these toxins reach the spinal cord only by the motor nerves, and never by the sensory nerves, the lymphatics, or the blood-stream. It has been further demonstrated that the poison is carried in these motor nerves by the axis-cylinders, but if these are destroyed by an injury (as in a crush or amputation of a limb) the poison may still reach some intact motor nerve by diffusion into the adjacent tissues. Once the spinal cord is reached, the poison is deposited in the motor ganglia, spreading upward from one to the other toward the vital centers of the medulla.

Varieties and Causes.—*Idiopathic tetanus* is supposed to be due to the inhalation of infected material.

Traumatic tetanus is the usual variety, and, as stated, it follows the entrance of the germs through a wound, ordinarily of the punctured, non-gaping, or non-bleeding sort.

Fourth-of-July tetanus is due to wounds from blank cartridges or revolvers, and all bullet wounds should be regarded as presumptively tetanogenic. Similarly, all wounds likely to be contaminated by manure or garden or street dirt are suspicious.

For purposes of description we also speak of *acute*, *subacute*, and *chronic tetanus;* the first develops within ten days and the others thereafter.

Cephalic tetanus follows wounds about the head, and in these the cranial nerves show the earliest effects.

Certain geographic localities seem especially likely to harbor the germs, and Anders[1] states that these places are in northern New York, the Hudson Valley, parts of Brooklyn, Long Island (notably Huntington), southern Pennsylvania, Virginia, Georgia, southern Louisiana, Indiana, Illinois, and southern California; and in New Jersey there is a small section where the infection appears endemically.

Symptoms.—There is nothing characteristic about the focus of origin, although most wounds will be infected and sinus-like and often found to contain dirt or foreign matter. Occasionally the initiating wound has healed before the tetanic evidences appear.

The nearer the wound is to the direct pathway of the spinal cord, the earlier and more severe are the symptoms; hence wounds of the head and upper extremity are more likely to give early manifestations than those situated more distantly.

In the *acute* form the incubation period is between seven and ten days, and the earliest symptom is stiffness of the muscles of the back of the neck, with or without an accompanying chill and rise of temperature. Difficulty in moving the jaw soon appears, and within a few hours definite lockjaw or trismus occurs, owing to the spasm of the masseter muscles. These muscles are supplied by the fifth nerve, and this is short and seems especially susceptible to the tetanus toxins. Soon the muscles of deglutition and expression are also affected, so that the so-called "risus sardonicus" occurs, together with more or less puckering of the forehead and eyebrows. Later the muscles of the trunk and abdomen grow rigid and tense, and subsequently those of the back and extremities (especially the lower) are likewise involved. Convulsive movements are induced by very slight causes, such as noises, trivial jarring, or even a puff of cold air.

These paroxysms vary in their severity, frequency, and duration, and they may be *tonic* or *clonic* in type. In some convulsions the rigidity of the muscles maintains the body often in an arched position, so that it rests on the heels and head alone (opisthotonos), or on the toes and forehead (emprosthotonos), or on the lateral margins of the face and leg (pleurothotonos). After the convulsion the patient perspires profusely and is much exhausted, although consciousness is fully maintained. The pain is said to be extreme in such a seizure, and these attacks may be so frequent that the vitality is speedily sapped, especially as the patient cannot swallow nourishment nor obtain sleep. Toward the end the temperature ascends and in the exitus respiratory failure occurs.

[1] *Jour. Amer. Med. Assoc.*, July 25, 1905.

Chronic tetanus shows a longer incubation period but has the same set of symptoms; however, the convulsions are less frequent and the intervals between them are longer. Relapse after apparent cessation may occur in this variety.

Treatment.—*Prophylaxis* aims to ward off tetanus by giving an immunizing dose of tetanus antitoxin in all suspicious cases, and these should include all bullet or blank cartridge wounds and all others likely to have been soil-infected.

Such an immunizing dose consists of from 1500 to 3000 c.c. of antitoxin injected above the wound subcutaneously; or, if feasible, directly into the nearest main nerves.

Curative Treatment.—(I) *General.*

(II) *Local.*—(*a*) The wound; (*b*) injections of antitoxin, carbolic, or magnesium sulphate; (*c*) sedatives, like bromids, chloral, morphin.

(I) *General measures* relate to the well-being of the patient, especially as to *feeding*. This generally is by a tube introduced through the nose; the food should be as concentrated as possible. The *room* should be dark and quiet, and capable nursing is especially important. Large quantities of fluid should be administered by the rectal drop-method or in definite plain water or saline enemata every four or six hours. Catherization is usually necessary.

(II) *Local Measures.*—(*a*) The *wound* should be opened and exposed freely to the air, all burrowing areas uncovered, and foreign bodies carefully removed. Iodin is poured freely into all crevices and allowed to remain a few moments, and any excess removed. Then the wound is flooded with hot peroxid of hydrogen or a deep pink solution of permanganate of potash. It is suitably drained by a rubber band or strand of tissue, or a tube, and a wet dressing of permanganate or iodin (1 dram to a pint) is applied. If there is any nerve exposed, antitoxin is injected into the sheath; if not, antitoxin is then injected into the tissues about the wound. If an amputation has been done, the flaps must not be tightly stitched, as every wound must be exposed to counteract so far as possible the anaërobic habits of the bacillus.

(*b*) *Injections.*—Of these, *antitoxin* is the most important, and it should be used in heroic initial doses, preferably injecting it into the nearest available large nerve trunks and also into the spinal canal. In wounds of the *upper extremities* at least 750 to 1500 units of antitoxin should be injected into the cords of the purposely exposed brachial plexus, and 3000 to 10,000 units are given intraspinally by lumbar or higher-level puncture, or, better, into the cauda equina, an effort being made to reach some of its fibers, as will be indicated by muscular

twitchings, it being maintained by some (Rogers notably) that if the fluid penetrates merely the spinal canal it can only reach the cord proper through the lymph-spaces, and thus, in effect, it is no more advantageous than if given intravenously. Laminectomy and direct injection of the cord has even been proposed.

In the *lower extremity* the intraneural injections are given into the sciatic, obturator, and anterior crural nerves, and the intraspinal route is also used as indicated.

If for any reason the main nerve trunks cannot be reached, the local injection can be given in the muscles above the wound or into a main vein of the trunk. Within twelve hours or earlier the procedure is to be repeated, as the antitoxin is relatively harmless. The route of choice in the early cases is *intraneural;* later, *intraspinal* and *intravenous* (750 to 3000 units). The *intracerebral* method of introducing antitoxin has not proved of value. Antitoxin, however, is not always obtainable, and when large amounts are required the treatment is relatively costly, as the wholesale rates are about $1.00 for each 1500 units; under these circumstances other materials may be used, as follows:

Magnesium sulphate (Epsom salts) has been used in the same manner as antitoxin, since Meltzer has shown the anesthetic effect of this drug when used either in afferent or efferent nerve-fibers. Under the personal direction of Dr. Meltzer the writer some years ago had the opportunity of demonstrating the anesthetic properties of this drug in major operations, and the employment of it in tetanus is based on the anesthetic more than the antitoxic or antiseptic properties. It is used in 25 per cent. solutions, 1 c.c. being used for every 20 pounds of body weight in a robust adult, or for every 25 or 30 pounds of body weight in the enfeebled, aged, or children.

Blake[1] has shown that each injection may, in favorable cases, control the convulsions for periods ranging from twenty-nine to thirty-seven hours. However, Camus,[2] by experiments on dogs, reaches the conclusion that the convulsions and excitability are but little influenced, even when this drug is used with carbolic acid to obtain the added antiseptic effect of the latter. He verified the efficacy of antitoxin and found it much superior to other means, even when they had been used combinedly. T. Kocher recently reported excellent results from the magnesium preparation, and he uses it in 15 per cent. solutions, repeating the intraspinal administration not oftener than each twenty-

[1] *Surg., Gynec.,* and *Obst.,* May, 1905.
[2] *Soc. de Biol.,* tome i, xxii, 1912, No. 31, p. 109.

four hours. He warns against using it if no cerebrospinal fluid flows after the spinal tap, and also advises care when it is employed with antitoxin. He regards it as in effect a hypnotic capable of warding off danger after the toxin has penetrated the nerve substance.[1]

Carbolic acid injection, "Bacelli's method," was introduced in 1888, and consists in the subcutaneous injection of 1 per cent. solutions until 80 grains are given daily to an adult. It is said to be rapidly eliminated and, therefore, must be frequently repeated. As is well known, this drug has analgesic as well as antiseptic qualities. This procedure has not much vogue now and was never very favorably regarded in this country, although the originator's Italian confrères reported fair success with the method.

Iodoform injection, "Kitasato's method," consists in the hypodermic introduction of 3 to 5 grains of iodoform three times daily.

Various other drugs have also been injected, such as salt solution, cocain, eucain, brain emulsion, and many others.

(*c*) *Sedatives* are needed for pain and insomnia, and of these the *bromids* and *chloral* are most often used, usually in the combination of "B. and C. mixture," containing 20 grains of bromid of soda and 10 grains of chloral hydrate, every three or four hours.

Chloretone, in 10-grain doses, is also of value. All of these drugs are generally given through a tube put into the nose or rectum.

Morphin is used hypodermically as needed, $\frac{1}{6}$ grain being the usual dose.

Prognosis.—Most deaths occur within the first week, and patients surviving this period usually recover, the majority of deaths occurring from respiratory invasion on the fifth day. The mortality in acute cases (those occurring within the first week) ranges between 75 and 85 per cent.; cases developing after the first week show a mortality of about one-half the foregoing. In the European War the antitoxin treatment of every wound has done much to prevent the development of this disease despite the bacillus-ridden soil.

RABIES (HYDROPHOBIA)

This infectious disease is due to the bite of a rabid animal, nearly all of the cases originating from dog bites. Cats, cattle, wolves, jackals, and all warm-blooded mammalia are capable of transmitting it, but horses and swine are rarely affected. It can be transmitted from animal to animal, and even birds are said to become infected.

Pathologically there are few characteristic changes, but the central

[1] T. Kocher, *Corres.-Blatt f. Schw. Aerz.*, Basel, xlii, No. 26, pp. 969–1000.

nervous system quite regularly gives evidences of hyperemia with hemorrhagic areas and occasionally softening, notably in the bulbar region, where a grouping of certain embryonic cells is often found near the central canal; these are known as "Babes' tubercles." The mucous membrane of the respiratory tract is generally inflamed and a frothy mucus is often present in large amounts. A positive diagnosis is now regarded as being made when small inclusion bodies or corpuscles can be demonstrated in the Purkinje cells of the cerebellum and in the large ganglionic cells of Ammon's horn; these are said to be protozoa, and are known as "Negri bodies."

Symptoms.—The *incubation period* following the bite is rarely less than twelve days and never earlier than five, the average being forty days in man, and twenty-one to forty in dogs (Bradford). The manifestations are said to be greatest when the bite has been on exposed surfaces so that the saliva has not been caught in clothing, and for this reason, and because of the contiguity of the brain, face bites are regarded as the most likely to become dangerous; those near to main nerve trunks act similarly, as the virus behaves like tetanus in choosing the most direct route to the central nervous system.

First stage symptoms are *irritative*, so that the wound is painful and the patient is restless, taciturn, ailing, or changed as to habits, actions, or appearance. Salivation may be excessive. This stage lasts two or three days.

Second stage symptoms are those of *excitement*, with more or less trouble in swallowing and some stiffness of the neck muscles. Efforts at drinking water often induces spasm of the glottis, but all food or drink may have a similar effect. Generalized convulsions may follow, with intervening great mental excitement and fear of death, or actual delirium, all of which are exceedingly exhausting. This stage may end in death after two or three days.

Third stage symptoms are *paralytic*, in which the lower extremities are first involved, and later the paralysis ascends and involves the respiratory mechanism, ending in death, usually within a day. Occasionally the early stages are absent and paralyses alone exist, constituting the so-called "dumb rabies" commonly seen in dogs.

From the onset of symptoms to recovery or death, a period of less than a week usually elapses.

Pseudohydrophobia, hysteric or otherwise, generally occurs within a few days of the bite, and is characterized by much frothing, barking, growling, or other canine manifestations that may last a long time, convulsions occasionally being added. Such cases generally arise from

fear, and some patients are said to have died from exhaustion and starvation even in this spurious form.

Prognosis is extremely bad, and genuine cases are nearly always fatal unless antirabic serum is given early. Cases may develop as late as a year or eighteen months after inoculation (Gowers), but it is exceedingly rare after six months (Bradford).

Diagnosis is made absolute by animal inoculation or by the finding of the Negri bodies.

Treatment.—*Prophylaxis* is exceedingly important, and all suspicious bites should be energetically cauterized or excised. Park, of the New York Board of Health Department, from a wide experience, advises fuming nitric acid as a cauterant, stating that ". . . in the case of small wounds all the treatment probably indicated will be thorough cauterization with nitric acid within twelve hours from the time of infection." Others advise applications of pure carbolic acid, silver nitrate, the actual cautery, strong solutions of bichlorid of mercury, or tincture of iodin. Under no circumstances should such a wound be sutured.

Since 1885 the Pasteur antirabic inoculation treatment has been advocated, and the average mortality in 30,000 cases receiving it at the Paris Pasteur Institute since then has been 0.5 of 1 per cent.[1]

The spinal cord of affected rabbits is utilized in making a graded virus which, when injected, establishes an immunity. This treatment is practically available all over the world, and in this country the Public Health Service or local Health Departments furnish it on demand when it cannot otherwise be obtained from commercial drug houses. To be of maximum efficiency it should be used just as antidiphtheric or antitetanic sera are used, that is, as an immunizing agent.

The *general treatment* requires no special comment.

Animals suspected of being rabid should be confined and observed. If within ten days a suspected dog does not develop rabies, then the disease does not exist; if it does develop, the animal will die, and the brain and spinal cord will furnish positive evidences of the exact condition. If a rabid dog has roamed about before being suspected, all other dogs in the community should be muzzled for from three to six months or until no further cases develop. Compulsory muzzling of dogs banished rabies from Great Britain in the period from 1903–07, and since then no cases have developed.

Dogs developing hydrophobia change in disposition ("furious

[1] Albert, *Jour. Amer. Med. Assoc.*, May, 1913.

form") or become paralyzed ("dumb rabies"). Long-haired animals are the least likely to be affected, presumably because the virus-laden saliva is caught in the hair.

Less than half the bites from animals actually rabid are followed by hydrophobia.

ANTHRAX (MALIGNANT PUSTULE; WOOLSORTERS' DISEASE)

This specific disease is rare in this country, and cases of it are generally imported from Russia, South America, China, and India, and these arise in connection with the handling of wool products, hides, horns, manure, horsehair, and rugs.

Koch, in 1877, determined the specific cause to be the *Bacillus anthracis*.

Symptoms.—There are three channels of infection: (1) Skin inoculation; (2) respiratory tract; (3) gastro-intestinal tract.

(1) Skin forms are also known as *cutaneous anthrax* or *malignant pustule*, and occur usually in a wound or break in the skin of the hands or face.

The incubation period is short, and at the onset a burning or itching small papule is seen, with a blue point in the center. In a few hours this becomes a vesicle containing a brownish or bloody fluid with a surrounding area of redness, swelling, and induration, and this zone later becomes purplish and gangrenous. The pain and itching then cease, and soon a halo of bloody vesicles appears and the original focus becomes an eschar, and the scab in about ten days falls off or it becomes necrotic. If the area becomes more swollen it resembles an erysipelatous patch and symptoms of sepsis may appear, but otherwise the constitutional signs are slight. In the severer cases the secondary vesicles may also become necrotic or gangrenous and involve large sections.

Edematous anthrax is a rarer manifestation, occurring in the loose tissues about the eyelids, neck, and forearm, appearing as an area of ill-defined edema without other cutaneous or systemic manifestations.

(2) *Pulmonary anthrax* is not unlike pneumonia, and is due to inhalation of dust containing the bacilli. It is fatal in 80 per cent. of cases within five days.

(3) *Intestinal anthrax* arises from eating the meat or drinking the milk of infected animals. Aside from signs like ptomain-poisoning, there are sometimes eruptions like carbuncles.

Diagnosis is promptly made by stains of the secretion from the

pustule, and animal inoculations kill the host within two days. Some cases simulate carbuncles, furunculosis, and erysipelas.

Treatment.—*General measures* consist in the use of Sclavo's serum, 10 c.c. or more being given into a vein adjacent to the pustule, this to be repeated within twenty-four hours if needed. When a vein cannot be chosen, the injection is given subcutaneously into the abdominal wall. Systemic supportive agents are also employed.

Locally the pustule is excised, or, when this cannot be done, the area about it is injected with 5 per cent. carbolic acid, to be repeated often. Caustic potash has also been injected around the pustule. Prior to the use of serum the mortality averaged 25 per cent., but now it has been reduced to about 5 per cent.

Workers in hides, wool, and other products likely to be infected should wear gloves and immediately sterilize all wounds; if dust is prevalent, a respirator should be worn and fans or other "blowers" employed to provide adequate ventilation.

GLANDERS (FARCY)

This is a specific disease due to the *Bacillus mallei* (Löffler and Schutz), and is very common in horses and less so in mules, field mice, rabbits, squirrels, guinea-pigs, cats, goats, and doves.

Contact with horses causes nearly all human cases, and the inoculation is by a skin wound or the respiratory or gastro-intestinal tract.

Symptoms occur soon after exposure, and at first the patient is regarded as having pneumonia because of the onset with fever, chill, pain in the chest, cough, râles, and expectoration. After a week or two hard swellings occur in the subcutaneous or muscular tissues, notably in the flexor region of the upper extremity and the pectoral and abdominal muscles. These later soften and become abscess-like, break, and emit a sanomucoid fluid. Sometimes a pustular eruption appears not unlike small-pox, although it never is umbilicated. The joints may also become swollen and the patient may be looked upon as rheumatic; synovitis may also appear, and if the joint is tapped the turbid fluid may show the bacilli. Sometimes a nasal discharge occurs.

After the second or third week delirium is common and the pulmonary signs increase, and death is then not long delayed.

Chronic glanders may last months or even years, and the breaking of the hard nodules and their ulceration may suggest gummata. These ulcerative areas may be very wide-spread and even involve the hard palate, face, nose, extremities, and other areas.

Prognosis is bad in the acute cases, as they nearly all die; about half the chronic cases recover.

Treatment.—Prophylaxis aims to disinfect promptly and vigorously all wounds occurring in those employed about stables or horses, and the primary focus should be excised when possible. Antiseptic dressings are then used and appropriate general treatment given to meet the constitutional symptoms. There is no specific remedy and the general signs are treated much after the plan of pneumonia.

ACTINOMYCOSIS

This specific disease is common in many domestic animals, and then is known as "lumpy jaw."

At one time it was supposed to be transmitted from animals to man, but now infected grain is regarded as the source of origin, either as a traumatic or actual inoculating element.

The *ray-fungus* found in the lesion is anaërobic, very tenacious of life, and grows in colonies of characteristic form, like grains of fine sand scattered through large-sized granulomata. These "sulphur grain" bodies are firm, grayish-yellow, red, and occasionally green or black, and they are readily visible and regularly present in the pus of the abscesses.

Most cases involve the head and neck, especially the region of the angle of the jaw, from a buccal port of entry; next in order of frequency the gastro-intestinal tract is involved, and then the respiratory tract and the skin. Spread of the process is along connective-tissue planes, as the disease does not progress along lymph-channels.

Symptoms.—*Cervicofacial* groups are the commonest, origin commonly arising from some abrasion of the mucous membrane of the mouth or from decayed teeth. Pain and difficulty in mastication are early signs, and the muscles concerned become rigid and a boggy, hard lump forms near the angle of the jaw, the glands not being involved. Trismus is present and is one of the main features, together with this very slowly progressing "lump." The skin becomes purplish, and soon areas of fluctuation appear and ulceration occurs with the escape of the characteristic bodies and the formation of sinuses or fistulæ that may enter the mouth. Pus is usually present due to a mixed infection, and the adjacent bone may also become necrotic. Extension to the tissues about the face and neck may occur, and occasionally the mediastinum may be involved, or it may travel upward and reach the base of the skull by way of the antrum.

Thoracic forms resemble bronchopneumonia, and the thoracic wall

or its contents may become involved, and finally many sinuses may appear. The average duration of these cases is ten months and the mortality is very high.

Abdominal forms arise from the intestinal tract, notably the ileocecal and colonic portion. The early symptoms may simulate appendicitis or colitis; in others, a tumor in the right iliac fossa may be an early sign. The skin over the invaded intestine eventually becomes gangrenous and sinuses form from which a grayish purulent material is discharged.

Cutaneous forms are exceedingly rare and constitute less than 5 per cent. of the cases. It manifests itself in a lupus-like manner with a localized nodule, or as an ulcerous lesion with necrosis in one part and dense granular infiltration in another. Later, the areas ulcerate and sinuses form, and these discharge the typical sulphur-like granules. It is a painless process and the glands are uninvolved.

Diagnosis is made positive in all cases by finding the characteristic granules and the ray fungus, and the slow progress of the actinomycosis process is also quite typical.

Sarcoma, carcinoma, tuberculosis, and gummata are often hard to differentiate.

Prognosis depends upon the location and the chances of mixed infection, the average mortality being about 47 per cent., the abdominal, thoracic, and cerebral forms being the most serious.

Treatment.—This is not very satisfactory, and consists of hygienic and dietetic measures, with appropriate antiseptic treatment of the local *ulceration* or *sinuses*, especially iodin dressings or a weak iodid solution, such as water, 500 gm.; potassium iodid, 10 gm.; iodin, 1 gm. Iodid of potash and sulphate of copper are said to be the drugs of choice for long-continued use. Excision of accessible areas is also advised.

MALIGNANT EDEMA (EMPHYSEMATOUS GANGRENE; GASEOUS PHLEGMON; BACILLUS AËROGENES INFECTION)

This is a rapidly spreading and usually fatal inflammation due alone to the *Bacillus aërogenes capsulatus anaërobicus of Welch*, which produces a gaseous infiltration of the tissues (clinically causing the same symptoms as the bacillus of malignant edema), or it may occur as a mixed infection due to pus-producing or other germs. It usually occurs with crushing wounds, particularly compound fractures of the extremities, or bullet wounds. In a recent fatal case of mine it appeared nine days after a multiple fracture of the pelvis with lacerations

of the vagina and urethra. Less often it has followed simple hypodermic punctures of the skin and abdominal and other operations.

The source of origin is supposed to be the human or animal intestinal tract, and in some of the cases the colon bacillus has been found, and by some is regarded as an almost identical source of origin. The European War has furnished vast numbers of cases as the soil is richly manured.

Symptoms.—These occur promptly, and usually within the first twenty-four hours the region of the wound will be found swollen, bluish, and edematous, and a fine crepitus will be felt over the involved portion. Most of the wounds emit gas-bubbling pus that is often brownish and characteristically fetid, and occasionally a definite crackling can be heard as the bubbles burst. Blebs sometimes appear and the original area of swelling grows rapidly, so that within a few hours the whole extremity may double in size, crepitation being present throughout. The purulent contents of the wound have a tendency to separate the muscles or lift them from the parts beneath, and the soft parts become cadaveric in appearance.

There is great systemic prostration and the temperature and pulse are much increased, and most of the patients die within a few days, the emphysematous swelling meanwhile having become quite general. There are apparently cases of lesser virulence in which the onset is later and the process much less general and severe.

Treatment.—General measures are those given to cases of sepsis. Proper initial sterilization of wounds doubtless prevents many cases, and wounds that in any way may have been contaminated by intestinal secretions are presumptively regarded as dangerous.

Inasmuch as the bacillus is anaërobic, the essential thing is to allow free access of oxygen, and for that reason the wound and the parts about it are freely incised and liberally flooded by hydrogen dioxid or strong solutions of permanganate of potash, and then the part is dressed by gauze soaked in these oxygen carriers. When the limb is involved, the propriety of immediate amputation must be considered, and this becomes imperative if wide incisions, drainage, and dioxid of permanganate are ineffective. The level of amputation should be above the zone of emphysema, as a rule, and the stump should be allowed to gape widely, as any attempt at coaptation may defeat the object of the procedure.

Recently the treatment by wide incision, drainage, dioxid, and permanganate has been reputed to be nearly as adequate as amputation if undertaken early and vigorously, several writers having demon-

strated the efficacy of these conservative measures, notably in the war zones.

SPOROTRICHOSIS

This local infection was first reported by Buermann, Paris, 1903, and to date about 200 cases have been recorded in literature. Hamburger[1] has stated that some 58 cases are now recorded in America, but that the disease is, in reality, much more prevalent, and is probably often confused with actinomycosis, blastomycosis, and other forms of granulomata.

It is due to the *sporotrichium*, which may become localized in the external soft parts, joints, bones, the lungs, kidneys, and other viscera. It occurs chiefly in farming districts, and inoculation is by a wound, usually regarded as trivial, as from a nail, barbed wire, or some farming implement.

Symptoms.—The onset is exceedingly slow, and the first sign is a "pimple" at the site of a visible or forgotten wound. Here a subcutaneous painful nodule appear sabout the size of a split pea, and within a few weeks similar nodes appear **directly above the original and in line with the lymphatics.** These gradually grow larger, and after six or eight weeks they break down and discharge a small quantity of viscid bloody pus and remain as painless ulcers without constitutional signs. In time these nodes may extend the length of the limb and may involve the deeper lymphatics also.

Beurmann states that there are clinically four varieties: (*a*) *Localized sporotrichosis*, with sporotrichotic chancre and ascending lymphangitis and lymphadenitis; (*b*) *disseminated gummatous sporotrichosis*, with diffuse nodulation and later cold abscess formation and no ulceration; (*c*) *disseminated ulcerative sporotrichosis*, with ulcerations like tuberculosis, syphilis, and other lesions; (*d*) *extracutaneous sporotrichosis*, with manifestations in mucous membranes, muscles, bones, joints, kidneys, and lungs.

Laboratory diagnosis is essential, and a local and general eosinophilia seems quite characteristic, and eosinophils have been noted in the original chancre, the pus, and circulating blood. The organism is of very slow growth and can be cultivated on glucose agar, giving characteristic branching, septate mycelium and pear-shaped spores.

Treatment.—Iodid of potash internally and iodid solution externally (water, 500 gm.; potassium iodid, 10 gm.; iodin, 1 gm.), are advised by Beurmann. The ulcerated areas respond to iodin applica-

[1] *Jour. Amer. Med. Assoc.*, Nov. 2, 1912.

tions, and the whole therapy is thus one of iodism, and the drug is to be given internally for at least a month after all visible lesions disappear. Salvarsan or neosalvarsan may later prove to be an efficient form of treatment.

Infections of the Hands

These occur so often that special mention of them will be made, with particular attention to the diagnosis of the type and focus of infection as determining the method of treatment.

Causes.—The largest number occur from apparently trivial abrasions or wounds that bleed but little and are wholly disregarded or reinfected by self-treatment with non-sterile materials. Many of the cases follow pricks from needles, pins, nails, glass, crockery, splinters, and other materials that carry infection more or less deeply and just as effectively as if deliberately inoculated by a hypodermic syringe. Deeper, longer, and more or less gaping wounds that bleed are far less likely to cause infection than the preceding, unless they have been sutured without adequate sterilization or drainage. A considerable number follow "hang-nail" infection and many are of unknown origin. Bruising alone without obvious breaking of the skin also is responsible for another small group of cases.

Certain occupations predispose to rapid and severe infections because the hands are more or less constantly covered with infected material. Butchers, hostlers, laborers, and house-wreckers seem especially prone, and the infections apparently become most virulent in those whose skin is calloused. The wearing of gloves and employments in which grease and oil smears the hands apparently confers a certain immunity.

Anatomy and Pathology.—A rational and simple description of the probable channels of infection has been given in Kanavel's work on Infections of the Hands, and his deductions will be very largely used in what follows. Hoon and Ross[1] admirably state their experiences with Kanavel's methods, and their statements are to some extent herein embodied also.

Given, then, an infection of the hand, pus may give rise to: (1) *Superficial infection* or (2) *deep infection.*

Superficial infection consists of—

(1) *Felons.*—Infection of the connective-tissue closed space that forms the pad of the tip of the front of the fingers.

(2) *Paronychia.*—Also called "run around"; infection of the subepithelial space at the side or base of the nail.

[1] *Annals of Surgery,* April, 1913.

(3) *Subepithelial Abscess.*—A purulent collection, usually at a finger-tip.

(4) *Carbuncles.*—Usually on the dorsal surface, proceeding from hair-follicle infection.

(5) *Collar-button Abscess.*—Also called "shirt-stud abscess," "frog felon," and "en bouton de chemise"; an abscess at the web of the palm under the dermal and epidermal tissues.

(6) *Thenar and Hypothenar Space Abscess.*—Purulent collections on the outer and inner side of the palm respectively.

Deep infection consists of—

(1) *Lymphangitis.*—Infection along lymph-channels.

(2) *Tenosynovitis.*—Infection along the tendon sheaths.

(3) *Fascial Space Infection.*—There are six well-defined spaces capable of harboring pus, and these are:

(*a*) *Dorsal Subcutaneous.*—An extensive area over the extensor tendons on the back of the hand.

(*b*) *Dorsal Subaponeurotic.*—Shaped like a cone, with the small end at the wrist and the broad end at the knuckles, and lying between the extensor tendon and the metacarpals.

(*c*) *Hypothenar.*—Localized on the ulnar side, and pus here tends to come to the surface.

(*d*) *Thenar.*—On the radial side of the middle metacarpal, lying deeply in the palm just above the adductor or transversus muscles.

(*e*) *Middle Palmar.*—Between the metacarpals and deep flexor tendons, reaching from the middle metacarpal and overlapped by the ulnar bursa and separated from the thenar space by a firm partition, except at the proximal end, where a small isthmus leads under the tendons and ulnar bursa into the forearm.

(*f*) *Web Space.*—Subcutaneous, at the web of the palm, with prolongation into the lateral margins of the fingers.

SUPERFICIAL INFECTIONS

Felons, Bone Felons.—These are inflammatory conditions of the connective-tissue space forming the pad of the front of the finger-tips.

Kanavel has demonstrated that the epiphysis of the distal phalanx is supplied by a branch of the digital artery *before* it enters this connective-tissue space, but the diaphysis of the phalanx receives its blood-supply *after* the artery enters this space. This arrangement accounts for the frequent involvement of the bone in neglected, severe, or improperly treated cases—the so-called cases of "bone felon," for the swelling within the space shuts off the blood-supply of the di-

aphysis and not of the epiphysis, because the artery to the former only functionates after it enters this crowded space, and hence necrosis and osteomyelitis frequently occur.

Causes.—Usually the sources are trivial wounds of the tip of the finger, especially small punctures from needles, pins, tacks, nails, glass, splinters, and other more or less pointed objects. Very rarely a bruise without a break in the skin is responsible. Many patients are unable to state the source of origin.

Symptoms.—Throbbing pain in the finger-tip, soon followed by swelling, redness, tenderness, and loss of function. A more or less localized cellulitis may also occur. Within forty-eight hours fluctuation is usually present.

Treatment.—Preliminary applications of wet or other dressings very rarely abort the process, and thus prompt incision and drainage

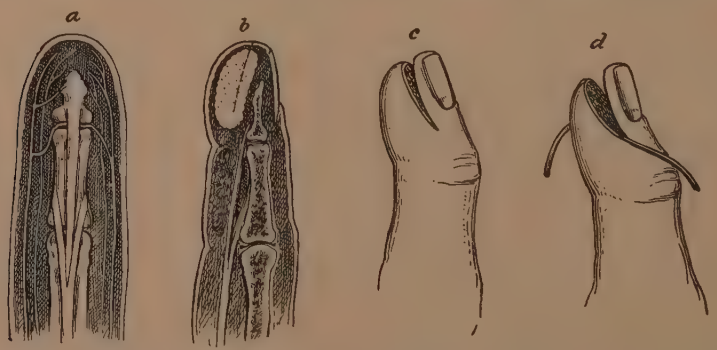


Fig. 23.—Felon of finger: *a*, Relation of vessels and tendons to bone of last joint; *b*, abscess zone—note line of incision; *c*, unilateral incision; *d*, bilateral or finger-split incision and rubber band drain.

is the best procedure. A general anesthetic should be given when possible, preferably nitrous oxid or ether. The incision advised by Kanavel is efficient, as it amply opens the closed connective-tissue space and leads to little subsequent deformity. This incision is over the site of greatest localized pain or fluctuation and is always made on the lateral margin of the digit down to bone. If there is general involvement of the entire finger-tip, an incision is made on both sides. No squeezing, irrigating, or manipulation should be done. Drainage should be provided by a fold of rubber tissue or a small rubber band (stationer's type) or a piece of rubber glove. A hot wet dressing of boric acid or salt solution is then applied and the part elevated. This dressing is daily changed, and when granulations begin the drain is removed and a dressing of gauze is applied soaked in balsam of Peru

and castor oil (10 to 50 per cent.) or gauze smeared with sterile vaselin. If the bone is denuded of periosteum and loose, it can be removed, remembering that the diaphysis alone will be affected; in such an event the finger will be stubby, but the joint will be unimpaired. Healing is often promoted by the use of a Bier or Klapp suction cup, and baking is also sometimes useful. Exposure to sunlight and air is perhaps, of all measures, the most valuable.

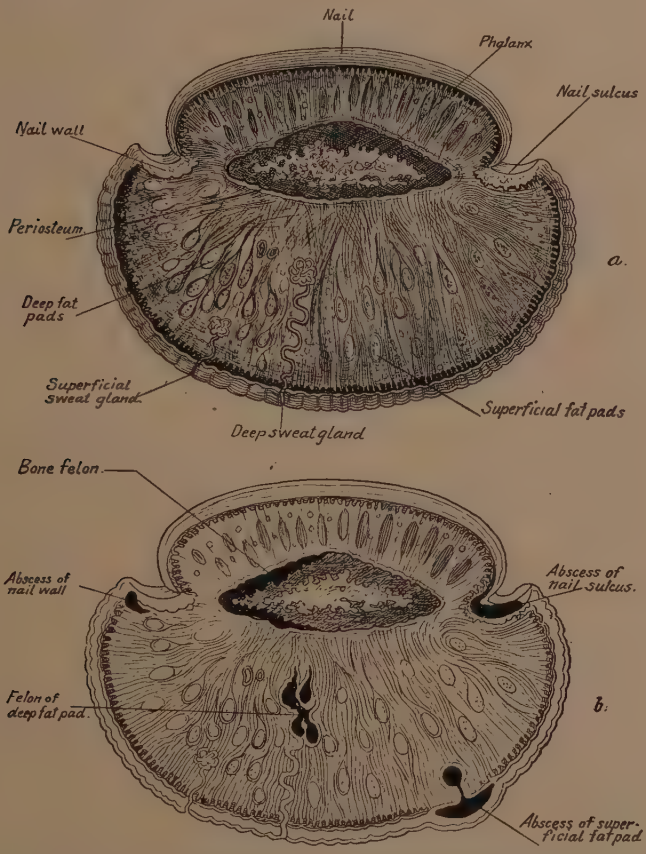


Fig. 24.—Infection of a distal phalanx: *a*, Cross-section showing normal structures; *b*, location of common infections.

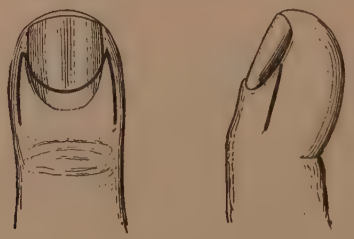
Dorrance[1] advises an incision at the tip of the finger just in front of the overhang of the nail, and thence carried straight upward so that the pad of the finger is practically bisected vertically (Fig. 23). This appears to be a method most useful in the severer cases only.

Paronychia; "Run-around."—This is an infection in the neighborhood of the bed of the nail.

[1] *Jour. Amer. Med. Assoc.*, May 10, 1913.

Causes.—A "hang-nail" is the usual source, and many of them follow ill-designed manicuring efforts (Fig. 24).

Symptoms.—Pain at one edge of the nail, soon followed by redness, swelling, tenderness, and a localized abscess. Some remain circumscribed and exude a few drops of pus on pressure, but others "run around" the base of the nail and give rise to a quite sharp cellulitis.

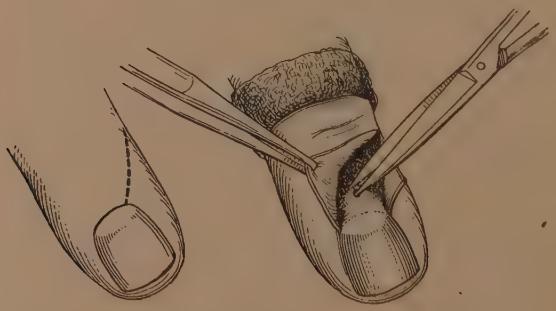


a *b*

Fig. 25.—Paronychia incision lines: *a*, Bilateral forms; *b*, unilateral forms.

Treatment.—They are rarely aborted by wet or other dressings. Incision and drainage is generally needed, and an anesthetic (nitrous oxid or ether) should be given.

Kanavel advises a lateral incision, passing upward from the base of the nail and so placed that the nail may be exposed, but not cut (Fig. 25). In some cases one lateral incision is enough, but usually each



a *b*

Fig. 26.—*a*, Incision for paronychia; *b*, flaps retracted and a portion of matrix about to be excised. This procedure is available for ingrowing nails also.

margin of the nail must be incised and then the skin over the matrix is rolled back as a flap. The bed of the nail is then raised by scissors and enough of it cut to allow escape of the pus beneath (Fig. 26). A folded strip of rubber tissue or a rubber band is inserted and the skin-flap replaced. The dressing is completed by loosely applying several

layers of gauze soaked in hot saline solution or boric acid. Daily dressings are made, and when the discharge lessens the rubber drain is shortened or removed, and then the part is covered by gauze smeared in vaselin, albolene, or 10 per cent. balsam of Peru in castor oil or glycerin. Motion of the adjacent joint should be made early to prevent stiffness. Children and others often develop lesions of this sort in rapid sequence, and such cases often present definite signs of systemic infection, and the general condition then requires much attention; plenty of fresh air and sunshine, suitable forced diet, and tonics should be given, and in some instances injections of autogenous or stock vaccines are of great value.

Furuncles, Boils, Carbuncles.—These localized collections of pus (furuncles and boils) are often seen wherever hair-follicles are present, and hence the dorsal surface of the fingers and hands are generally

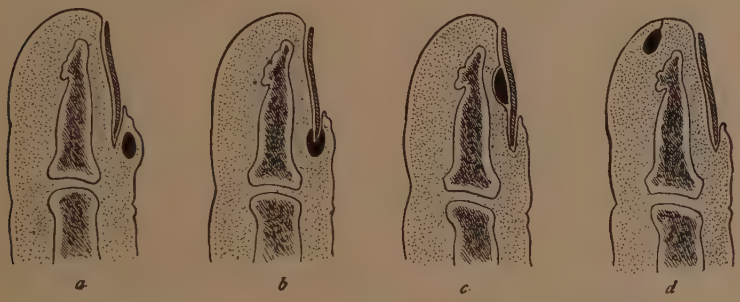


Fig. 27.—Usual location of pus foci near finger-tip: *a*, Outside base of nail; *b*, within base of nail; *c*, under body of nail; *d*, in finger pad.

involved. If the process is deeper, wider, and more severe, then it is of the carbuncle type (Fig. 27).

Causes.—The infection is ordinarily of the staphylococcus type, but it has been demonstrated that virulent streptococcic cultures may induce carbuncles when rubbed into the tissues.

The hair-follicles and the sweat-glands alike may be sources of infection, but a break in the skin is very rarely a demonstrable source of origin, and hence wounds and bruises and other acute traumata are very rarely causative agents. Constant, repeated, or chronic irritation is the most likely cause, and in many cases a depleted condition of the system doubtless plays a part. This, however, is by no means constant, as "crops" of boils and carbuncles often attack athletes and others in the best of physical condition.

Symptoms.—Furuncles and *boils* begin like a pimple and soon get larger and more painful and develop a white center of pus, a hair-

follicle ordinarily standing in the center of this area of localized necrosis. They often are multiple or appear in series more or less close to each other in point of time.

Carbuncles may be regarded as multiple subcutaneous boils, and they begin with pain, throbbing, redness, heat, and swelling, and these signs may last some hours or days before elevation of the skin appears or pus points become visible. They sometimes are manifestations of a diabetic, nephritic, or other systemic condition, especially if recurrent. The infection ordinarily travels downward in one of the columnæ adiposæ and spreads in the subjacent fat and proceeds to undermine to a variable extent, gradually filling the loose meshes under the skin until it overflows toward the surface along the various columnæ, thus accounting for the numerous pus points seen in the lesion. The central part of the subcutaneous process becomes necrotic, this constituting the "plug" or "core." The surface of a fully developed carbuncle is somewhat zonal, the center being necrotic; around this is an area of punctate, pus-exuding tissue; still beyond is a bluish area of venous stasis, and the outside rim shows an area of inflammatory reaction constituting a periphery of induration. Much constitutional weakness with fever and chills often accompanies the condition, and in the aged or weak the outlook may be quite serious. In passing, it may be stated that carbuncles of the neck, and particularly of the face, are even more dangerous because of septic sinus thrombosis.

Treatment.—Boils sometimes can be aborted by a hot wet dressing of saline or boric acid solution. The injection of carbolic and other solutions into their center is advised by some. To me this seems just as painful and far less certain than the curative incision. Once the lesion is established, incision and drainage (rubber wicking or band) is the best remedy. Hot wet applications of boric or saline solution complete the dressing. Cupping is often very valuable. Recurrent cases are sometimes benefited by autogenous or stock vaccines.

Carbuncles cannot be aborted, and early liberal incision with adequate drainage should be made at once. An anesthetic should be used, nitrous oxid being the best. The incision should be crucial and extend beyond the edges of the indurated area deeply enough to penetrate to the necrotic base. Any loose plugs of pus should be removed. Spurting vessels should be tied, but oozing will be cared for by the dressing. The edges of the four flaps created by the +-shaped incision should be undermined by scissors and then elevated, the whole cavity being packed with gauze wet in saline or boric solution. If there is little oozing the gauze may be smeared in vaselin or

albolene. The cyanosed or necrotic skin should not be excised until it definitely breaks down, and its vitality will often prove surprising and gratifying if left alone. Cupping will be of service. No squeezing should be done. When the sloughs have separated, healing will be promoted by filling the cavity with pure or diluted balsam of Peru, vaselin, or albolene. Surface granulations will be encouraged by scarlet red ointment, and grafting will be needed only in very extensive cases. Exposure to air and sunlight will be very helpful. The general nutrition must be well watched.

This treatment applies also to carbuncles of the neck and elsewhere. In some cases exsection of the entire necrotic area with subsequent suture may be advisable.

Collar-button Abscess, Shirt-stud Abscess, Frog Felon.—This is an abscess located at the web of the finger, and it commonly occurs in working-men or others who have calloused palms. The nature and site of the lesion is well indicated in Fig. 40. The peculiar dumbbell shape is due to the hypertrophy of the epithelium, which makes a dense sheet under which the pus spreads, and a subdermal infection passes through this to the epidermal tissue, where a second abscess develops, thus giving the collar-button appearance to the pus collection. The process may be reversed, locating primarily in the epidermis and thence spreading to the dermis; according to Kanavel, it is possible that this latter process is the more common.

It is frequently an occupational occurrence due to constant irritation of the area, leading to cracks or lowered resistance of the surface.

Symptoms.—Pain, swelling, redness, heat, induration, and fluctuation occur, causing loss of function of the involved portion. Attention must be directed to areas of involvement on the dorsal surface also, so that burrowing pus may there be detected promptly.

Treatment.—Incision and drainage at the web and finger junction should be made early. Ethyl-chlorid spraying affords sufficient anesthesia. Drains should be of rubber tissue or rubber bands. The dressing is of gauze wet in salt or boric solution.

Thenar and Hypothenar Space Abscesses.—These generally occur from punctured wounds, and ordinarily the pus readily escapes to the surface without serious damage. Much swelling of the dorsum of the hand occurs in some of these cases, and this may lead to incisions improperly placed, especially in the thenar region.

The hypothenar space is a closed area, and infections here are generally direct implants and tend to remain as localized abscesses.

Treatment is incision and drainage.

DEEP INFECTIONS

Lymphangitis.—This is an inflammatory condition of the superficial or deep lymph-channels.

Causes and Symptoms.—Some break in the skin, usually a superficial wound or abrasion, starts the process. Most cases occur in the fall and winter, and workmen and others with calloused hands furnish the largest number of cases. The usual infecting agent is the streptococcus or staphylococcus, but dual infection is very common; such a "mixed infection" usually indicates a prolonged attack.

It is important to remember that from any given point the superficial lymphatics take the shortest route to the dorsal surface; hence very marked signs appear on the posterior aspect, although the focus lies anteriorly.

The onset is usually prompt, and often within a few hours the process is well developed, and it is rarely delayed longer than twelve hours from the period of infection. Locally, the part is reddened and swollen and the characteristic red streaks are seen passing upward from the zone of infection to the nearest glands. These streaks are rarely continuous or numerous, and on the ulnar side (little and ring finger) they lead to the epitrochlear glands, which are found to be swollen and tender. The lymphatics on the radial side (thumb and index-finger) lead to similarly swollen and tender axillary glands. Infection beginning in the middle finger may lead to either the epitrochlear or axillary glands. Generally speaking, involvement of the radial side is more likely to be severe because infection is carried more directly into the main circulation.

The usual signs of systemic infection often occur, such as malaise, headache, fever, restlessness, thirst, and sometimes chills and considerable prostration.

In some cases the originating focus cannot be located, but ordinarily it is apparent as a swollen, red, hot and tender area, and a good deal of swelling generally is found on the back of the hand, notably when a finger is the portal of entry.

In the deeper types of involvement the foregoing signs may be exaggerated and the whole extremity may then be intensely swollen and brawny, resembling erysipelas; this is the so-called "phlegmonous lymphangitis."

Whatever form is present, it is important to exclude *tenosynovitis* and abscess of the *fascial spaces* by noting that the fingers can be moved painlessly, and that pressure along or functionating of individual tendons does not cause localized or added pain, and that there is no localized bulging, pain, or fluctuation of the main fascial spaces.

Rarely tenosynovitis and fascial space infection may develop from lymphangitis. Kanavel is of the opinion that from 10 to 15 per cent. of the cases become localized as abscesses, either of the tendon sheaths, fascial spaces, or glands.

Infections of the thumb, index, and middle fingers seem most likely to be associated with systemic symptoms, because the radiating lymphatics reach the axilla before meeting any check, and thus the general circulation is more readily reached than if the process halted at the elbow, as in infections of the ulnar side which are stayed by the epitrochlear glands.

Deep Lymphangitis.—This is much less common than the preceding superficial form. The deep lymphatics follow the course of the brachial artery and its branches as a rule. Many of these cases are associated with superficial lymphangitis, and they generally are of severe type, resembling erysipelas. They produce high fever and profound systemic depression from a generalized toxemia. Localized abscesses are rare, but metastases are common and septic pneumonia is a not infrequent sequel.

Systemic infections of this general type are especially liable to be fatal in those over forty-five years of age and in alcoholics, nephritics, or the debilitated. Abscesses are likely to develop in various parts of the body, the kidneys become seriously embarrassed, and a "general sepsis" often occurs.

Treatment.—Early Cases.—Here it is understood that no pus focus exists, and treatment is indicated for relief of pain, swelling, heat, and radiating streaks. If there is an initiating focus, as an open wound, this is first suitably sterilized by swabbing with iodin and then drained by rubber tissue or rubber bands. It and the area involved are liberally covered by gauze moistened in a hot saturated solution of boric acid or normal salt solution, many layers being applied, reaching much beyond the reddened area. The entire dressing is covered by paraffined paper, oil d silk, or rubber tissue, holes being cut in it so that a syringe may be inserted and the gauze remoistened without changing the entire covering. Usually such remoistening is required every four hours. This same treatment is given cases in which no incision is indicated or in which no wound of entry exists. Care must be taken not to cut off circulation by bandaging, especially in the forearm. In some cases a 25 or 50 per cent. alcohol dressing seems to act better. Carbolic solutions must never be used, and, in fact, that drug should be used in surgery only as a cauterant. Antiseptics of various kinds, like bichlorid, have no inherent virtues over salt or boric acid. In an odorous wound, tincture of iodin (1 dram to 1 pint of water), or a good

pink solution of permanganate of potash, or 1 per cent. creolin will abolish odor. Dakin's solution (or eusol), based on the war zone experience, is also of value in many infections with pus discharge.[1]

The part is kept at *rest*, and for this purpose a broad dorsal or palmar splint is very effective, and elevation of the extremity should be insisted upon.

Bier's bandage sometimes seems of value if used early. It is applied by taking turns of a broad rubber bandage from the elbow to the axilla, making pressure enough to restrict the venous return. It is worn for several hours, and in some cases is kept in place as long as eighteen hours. It should not be tight enough to cause persistent (1) pain, (2) cyanosis, (3) coldness, (4) tingling, (5) loss of function. If any of these are continuous, the pressure is too great and damage will result. The constriction must be broad, so that the nerve-supply will remain undamaged. If beneficial, it can be removed and reapplied as occasion demands. A good working rule for its use is: on six hours, off one hour; off during night or when patient is away from direct observation.

Incisions in Later Cases.—Opinions vary as to their value except in the presence of definite induration, fluctuation, or other evidences of pus collection. The theory is that a vertical incision in the area of redness or one transverse to the lymphatic streak will allow the escape of serum and tend to direct bacteria to the surface. This is questionable, and in many instances such a procedure opens up new channels of infection, and it cannot reach bacteria already at a distance from a place of known or unknown entrance. Personally, I never incise unless pus has collected.

Occasionally along the line of the lymphatics (especially on the back of the hand) may be seen small bean-sized areas of swelling and tenderness *without fluctuation;* it is an error to incise these, as usually a chill and increase of fever follows such interference. If incisions are made, the spread of infection may to some extent be limited by the use of a Bier bandage before making the incision and allowing this to remain in place from twelve to eighteen hours.

General Measures.—Food is of great importance, and these patients should be fed often, preferably liquids and easily digested stuffs like milk, soups, broths, eggs, and the like. Feeding every three hours

[1] Sodium hypochlorite solution (*Dakin's solution*). This is a watery solution of sodium hypochlorite in a strength of 0.5. It is made as follows: Dry carbonate of soda 140 grams, mixed into 10 liters of sterile water. Add 200 grams of chlorid of lime. Shake well. In half an hour siphon off the clear fluid through cotton or paper, and to this clear fluid add 40 grams of boric acid. The fluid should be neutral in reaction. It should be renewed if a precipitate forms. If too acid or irritating it can be neutralized by normal salt solution.

is a good practice—a little at a time in a very concentrated, palatable, and inviting form. Rectal feeding must be used when the stomach is intolerant. Large amounts of water must be provided, and this can be given rectally by the "Murphy drop method" if desired.

Fresh air acts well in all forms of sepsis, and these patients do better if kept out of doors with adequate protection all the time.

Drugs, like quinin and strychnin, I believe act well; they should be given in capsule or tablet form in doses of 3 grains of quinin and $\frac{1}{30}$ grain of strychnin every four hours. Whisky is often of great value, and my habit is to prescribe $\frac{1}{2}$ ounce every four hours with the above tablet or capsule. In alcoholics it is an essential, and then should be

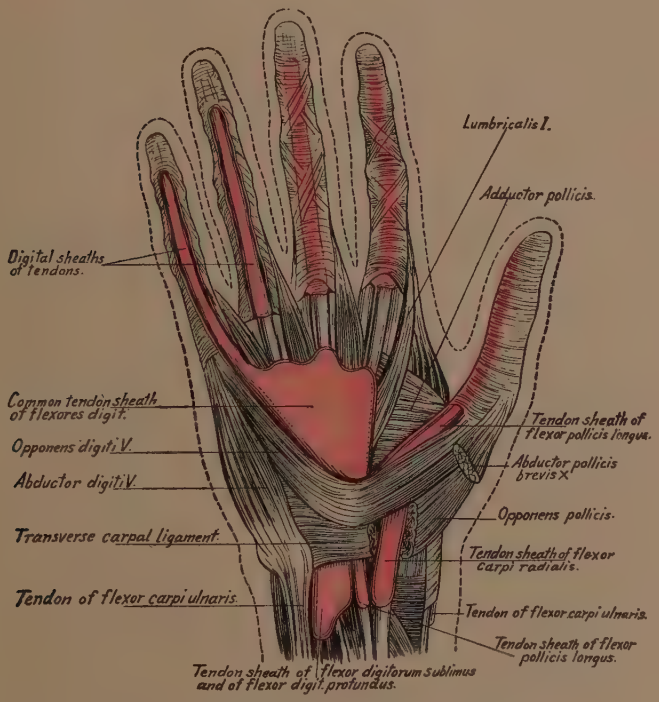

Lumbricalis I.
Adductor pollicis.
Digital sheaths of tendons.
Common tendon sheath of flexores digit.
Opponens digiti V.
Abductor digiti V.
Transverse carpal ligament.
Tendon of flexor carpi ulnaris.
Tendon sheath of flexor digitorum sublimus and of flexor digit. profundus.
Tendon sheath of flexor pollicis longus.
Abductor pollicis brevis.
Opponens pollicis.
Tendon sheath of flexor carpi radialis.
Tendon of flexor carpi ulnaris.
Tendon sheath of flexor pollicis longus.

Fig. 28.—Flexor tendon sheaths of the palm.

used in combination with sodium bromid, 20 grains, and chloral hydrate, 10 grains, every four hours, until the patient sleeps or the tremor of the tongue and fingers is controlled. If not well tolerated, it may be given by rectum.

Serum and *vaccine treatment* is not of proved value in acute cases, but appears to be somewhat beneficial in those of long duration.

Summary.—Incisions are inadvisable unless focal evidences of pus exist.

Hot moist dressings of boric acid give the best results.

General treatment must not be forgotten, especially fresh air, forced feeding, plenty of water, and, in alcoholics especially, some whisky.

Suppurative Tenosynovitis.—The involvement of a tendon sheath may occur primarily, but is ordinarily an example of progression from an adjacent focus. It nearly always occurs on the palmar surface, especially in the sheaths of the distal and middle phalanges. Many of the cases are of the streptococcic variety and necrosis is apt to be very prompt, and once it occurs, the future functional value of the finger is quite problematic.

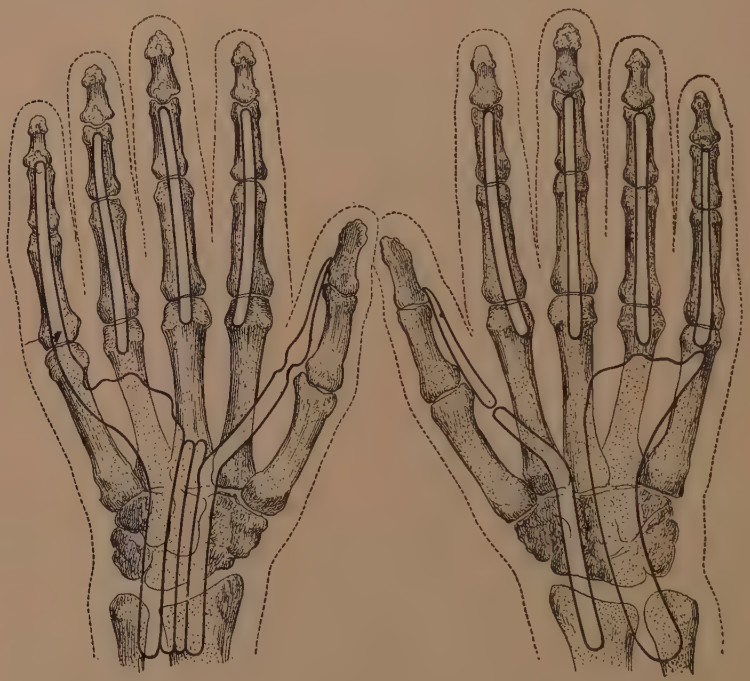


Fig. 29.—Tendon sheaths of palm and their usual arrangement.

Causes.—Many arise from trivial punctures that bleed little if at all; others are due to open infected wounds that originally invade the sheath or soon reach it because of contiguity.

Tendon Sheath Infection.—The most important sheaths are on the flexor surface, thus:

(*a*) The tendon sheaths for the index-, middle, and ring fingers, extending from the middle of the distal phalanx to a line joining the inner end of the distal palmar crease and the outer end of the proximal palmar crease, "Kanavel's line" (Figs. 28, 29).

(*b*) The tendon sheath for the thumb with its prolongation in the hand via the radial bursa, reaching to the lower end of the radius.

(*c*) The tendon sheath for the little finger and its prolongation in the palm via the ulnar bursa, reaching to the lower end of the ulna.

(*d*) The intercommunication of these sheaths.

The six synovial sheaths on the dorsal surface are not surgically very important, and they are sufficiently well indicated by reference to the diagram (Fig. 30).

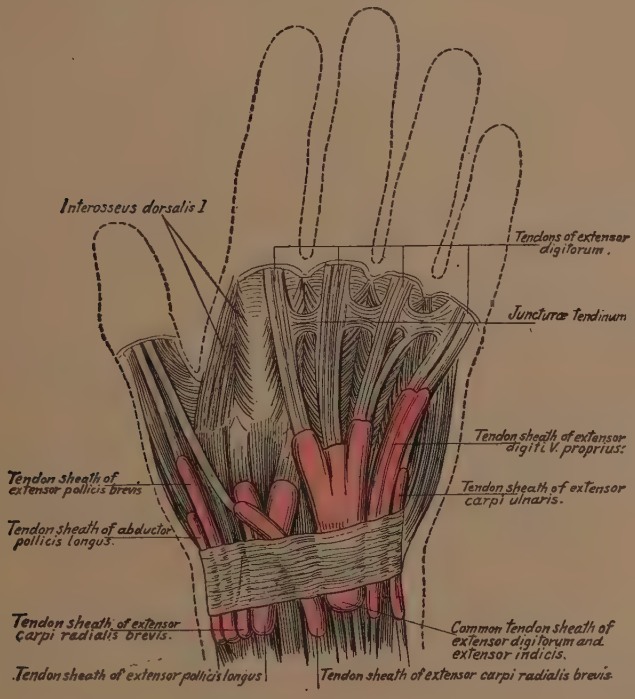

Interosseus dorsalis 1
Tendons of extensor digitorum.
Junctura tendinum
Tendon sheath of extensor digiti V. proprius.
Tendon sheath of extensor pollicis brevis
Tendon sheath of extensor carpi ulnaris.
Tendon sheath of abductor pollicis longus.
Tendon sheath of extensor carpi radialis brevis.
Common tendon sheath of extensor digitorum and extensor indicis.
Tendon sheath of extensor pollicis longus
Tendon sheath of extensor carpi radialis brevis

Fig. 30.—Extensor tendon sheaths of the palm.

It has been shown that extension to the forearm of infected material from the deeper portions of the hand is from the ulnar or radial bursa or the midpalmar space, and that pus from either of these foci invades the same area of the forearm. This lodgment of pus is under the flexor profundus digitorum tendons and muscle. About 3 inches up on the forearm the pus begins to invade the intermuscular septa, passing first to the area about the median nerve, and later to the area about the ulnar artery and nerve, and here it lies between the flexor carpi ulnaris and the flexor profundus. This is about 4 inches up on the forearm. From here it may pass along the vessels and nerves, particularly the median nerve, or, more commonly, it may extend distally along the ulnar artery under the flexor carpi ulnaris and appear sub-

cutaneously about 3 inches up on the ulnar side. Uncommonly it may extend downward along the radial artery. The larger portion of the space is about 2 inches above the wrist, and the most superficial parts are on either side just volar to the ulna and radius. The floor of this space is formed by the pronator quadratus at the wrist and the interosseous septum above. The space may hold ½ pint or more of fluid. The only other distinctly separated space is that comprising the subcutaneous tissue (Fig. 31).

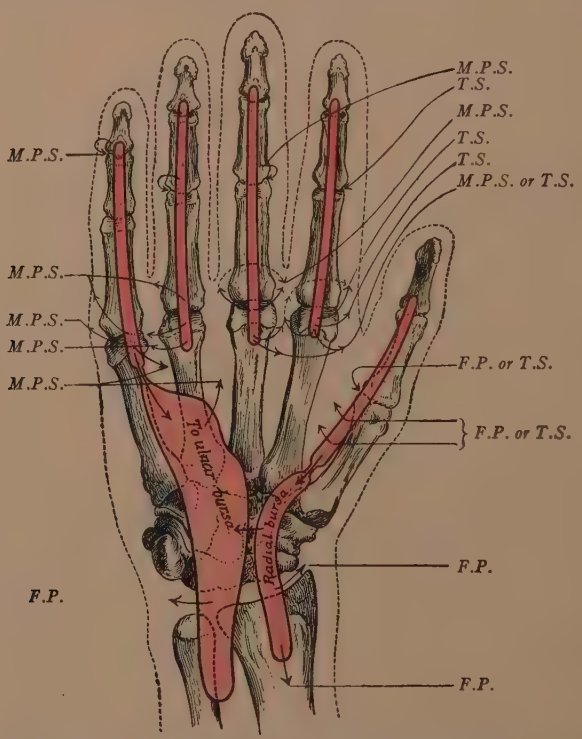


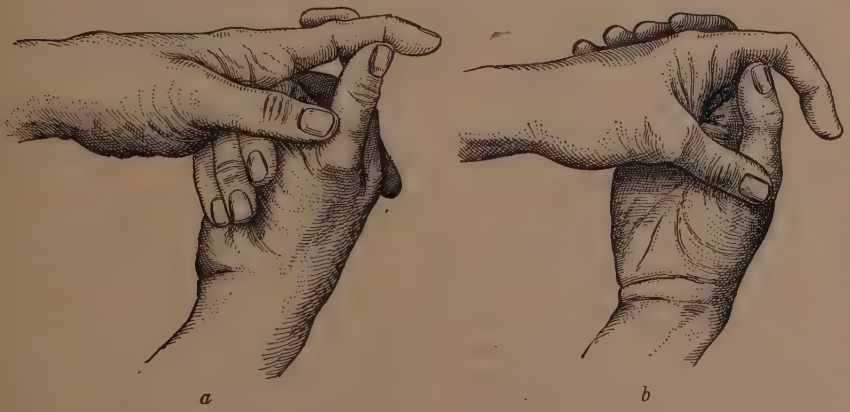
Fig. 31.—Possible routes of extension of infection from the palmar tendon sheaths. Arrows indicate supposed site of wounds and the figures and lettering the probable routes of infection therefrom: *M.P.S.*, to middle palmar space; *T.S.*, to thenar space; *F.P.*, to flexor profundus digitorum region. Note that *thumb* infections tend to spread to *F.P.*; *index-finger* infections, to *T.S.*; *middle*, *ring*, and *little finger* infections, to *M.P.S.*

Symptoms.—It is often difficult to differentiate between tenosynovitis, lymphangitis, and fascial space infection, but the cardinal signs of any tendon sheath invasion are:

1. Pain limited to the course of the sheath.
2. Flexion of the involved finger, especially at the web.
3. Pain on extension, notably at the palm.

A well-marked case will exhibit a more or less swollen hand, with perhaps a dirty wound at a finger-tip, swelling of one border of the

palm, and much edema on the dorsal surface; in other words, the tenosynovitis may coexist with a fascial space abscess or lymphangitis. Careful examination will probably show that the most exquisite pain occurs on pressing along the front of the finger or by attempts made to straighten it (Fig. 33). If the infection is delimited, the chances are that it is of the staphylococcic variety, which tends to produce a plastic exudate, thus making the process quite local and gradual in onset. If, however, the development is rapid and quite general, the infecting agency is probably streptococcic, and this is characterized by a purulent exudate of marked virulency. This sort of infection has a marked tendency to spread to adjacent spaces, and when it thus bursts from the sheath the cessation of pain may fool the patient and physician much in the same way that a ruptured appendix with subsidence of pain may give a sense of false security and a belief of danger passed.



a *b*

Fig. 32.—Test for tendon infection or division: *a*, Index flexor active; *b*, index extensor inactive.

The possible lanes the infection may traverse in respective fingers are given in Fig. 31.

The diagnosis of such extension is often quite difficult, but in the main depends upon the presence of swelling, localized pain on pressure and motion, and the finding of fluctuation in advanced cases.

Treatment.—This depends upon the stage of the process, the type of infection, the presence or absence of an original wound, and, to some extent, on the tendon involved.

Any operative procedure should be done with the aid of a general anesthetic—nitrous oxid, ethyl chlorid, or ether being given the preference. In most cases it is impossible to make an adequate exploration or incision with local anesthesia, and if the treatment is to be effective it must be adequate. Small incisions are useless and result nearly

always in added destruction and re-operation, often at a time when the patient is in poor condition to resist further interference. It is generally better to operate in a bloodless field, and for that reason a wide rubber bandage makes a good tourniquet, and it may be allowed to re-

Fig. 33.—Tourniquet applied to induce hyperemia of forearm or hand, after the method of Bier.

Fig. 34.—Line of incision for tenosynovitis of a finger: *a*, Distal phalanx; *b*, medial phalanx; *c*, proximal phalanx. Note that the incisions do not cross the palmar creases and are placed laterally.

main in place several hours, to be then gradually loosened, so that Bier's hyperemia effect is obtained (Fig. 33).

The incision should be made as soon as tendon involvement is recognized, as further delay is dangerous and may lead to irreparable damage.

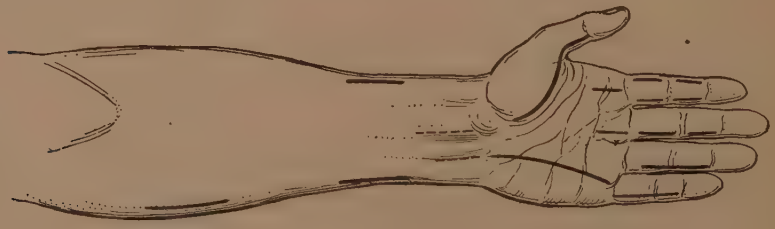


Fig. 35.—Lines of incision to reach pus-pockets in fingers, palm, and forearm.

The first cut is made at the place of known infection, and the tendon is reached on the *lateral* and not on the *front* aspect of the finger (Fig. 34). If necessary a lateral incision can be made on the opposite side of the phalanx also.

The sites for incisions to open various tendon sheaths are indicated in Figs. 35–37.

Care must be used in making the incision sufficiently long and deep, but if possible it must not cross the creases between the joints of the fingers, for that would open up the joint to infection and result in much loss of function. When the sheath is opened, pressure above it will show whether pus has spread beyond the limits of the incision, and if so, an opening must be provided higher up. The location of these additional incisions is indicated by the diagram.

It is almost never necessary to attack the tendons of the distal phalanges.

Index-, *middle*, and *ring-finger extension* to the lumbrical space on the outer side may lead to thenar space involvement, and the incision

Fig. 36.—Lines of incision to drain pus collections at web and midpalm, showing "Kanavel's triangle" of midpalmar space.

Fig. 37.—Line of incision for extensive palmar abscess.

that opens the lumbrical space can be extended to the thenar also. If this is inadequate, the incision may then be continued behind the web of the thumb to the base of the latter, and then the point of an artery forceps is thrust across the front of the index metacarpal, the blades opened, and this then will drain the thenar space without making an opening in the palm. If the forceps are pushed beyond the ring-metacarpal bone the middle palmar space will be opened and infected.

If the infection has entered the lumbrical space between the index- and middle finger the incision should be made into the ulnar side of the sheath. If the spread involves the back of the hand, an incision over

the dorsum opposite to that on the palmar surface should be made, and at times it may be necessary to cut right in through the web.

Proximal extension demands that the original incision be extended along a director so that the middle palmar or thenar spaces may be reached if necessary. This extension of the incision is made about $\frac{1}{4}$ inch proximal to the line joining the ends of the distal palmar creases, an artery forceps being thrust into the space under the tendon.

Little finger extension is treated as in the preceding, except that one long incision on the inner side of the finger seems better than two of smaller size.

Extension along the tendon toward the wrist demands incision, as indicated in the diagram, keeping well toward the inner side of the palm. When the anterior annular ligament is reached, pressure above will show if pus has gone into the forearm. If it has, a point on the palmar surface about $1\frac{1}{2}$ inches above the tip of the ulna styloid is chosen, and here an incision down to the bone is made. A closed artery clamp is then thrust through this, across the front of the forearm to a corresponding level of the radius, and then the clamp is impinged against the skin and cut down upon. This gives a side-to-side opening under the tendons, and free drainage will be afforded by enlarging the skin wounds up to about 2 inches in length. Care must be used so that the incision does not invade the radial or ulnar artery. This incision adequately opens the upper end of the ulnar bursa, and from it drainage can be obtained laterally and even into the lower end of the space. In some cases, where the bursa is alone involved, the ulnar portion of the incision alone will prove adequate. The operator must be on guard in such a case to make the incision deep enough to reach the area *under* the profundas, as this section between the flexor profundas tendons, the interosseous septum, and the pronator quadratus is always first involved when extension occurs upward. If the lateral incisions seem inadequate, it may be necessary to provide drainage upon the anterior surface, and thus the annular ligament may have to be cut, and this should be done as far toward the ulnar side as possible.

In all these cases adequate drainage is afforded by strips of rubber tissue or pieces of rubber band, or strands of gauze soaked in vaselin. Many cases require no drainage, and under no circumstances should dry gauze or heavy tubing be used.

Extension further into the forearm is treated by incisions planned as shown in the diagram. Those on either side just above the wrist (as indicated above) are particularly useful.

The majority of cases require incision on the ulnar more than on the radial side. Usually an incision between the ulna and the flexor carpi ulnaris half-way up the forearm is the most satisfactory if upward spread has occurred, and it may be lengthened to 3 or 4 inches. This incision, together with the lateral cuts just above the wrist, affords enough drainage for nearly all the cases, and the combination is much more effective than a series of cuts on the flexor or radial surfaces. Occasionally a subcutaneous incision just above the flexor surface of the middle of the wrist may be needed.

If *secondary hemorrhage* occurs, it is nearly always from the ulnar artery, and then it is generally best to ligate this vessel promptly if the bleeding is severe or the patient depleted; otherwise pressure by gauze may be effective.

Thumb long flexor extension is reached by an incision beginning at the proximal phalanx, thence reaching through the muscular bellies of the thenar eminence, and thence upward to within 1 inch of the lower border of the anterior annular ligament. Here the incision stops because the motor nerve of the thenar muscles is in very close proximity.

The upper end of the radial bursa can be drained through the side-to-side incision above advocated for ulnar bursa involvement.

Necrosis of the tendons may make an anterior incision advisable, and in this event the line lies $\frac{1}{4}$ inch outside the middle of the flexor surface. If the tendon is wholly necrotic, time will be saved if it is removed without waiting for it to spontaneously slough out.

After-treatment.—Irrigation of the part, if necessary, is made with boric or saline solution, but no strong antiseptics are used.

Drainage, as stated, is by rubber tissue, rubber bands, or vaselin-soaked gauze. Drains should be removed as soon as possible.

Dressings are of gauze soaked in hot boric or saline solution. They are used for only a few days, as they cause maceration, and dry gauze is then substituted. If there is odor, permanganate solution (a good pink color) or iodin (1 dram to a pint of water), or 1 per cent. creolin may be used.

A dorsal splint well padded keeps the fingers in extension, **but at each dressing the digits are gently flexed to prevent adhesions.** If the tendons at the wrist have been exposed, the hand is so dressed that it bends backward at a right angle to prevent prolapse of the tendons and consequent deformity (Fig. 38).

Adhesions are prevented by early passive motion, and this in many cases should begin at the first dressing and must never be delayed beyond the third day. Motion may begin actively about the same

time, and this is rendered less painful if gently performed with the hand immersed in hot water. Later, massage, baking, baths, and exercises

Fig. 38.—Dorsal flexion of wrist to prevent retraction of flexor tendons in suppurative tenosynovitis.

may be prescribed. Bier's suction cups and Klapp's apparatus are also of value.

FASCIAL SPACE INFECTIONS

These may occur primarily or in association with tenosynovitis (Figs. 39, 40).

Treatment is at first by wet dressings of saline or boric solution, in the hope that pus formation may be prevented or limited. If, however, an abscess has formed, incision and drainage must be instituted.

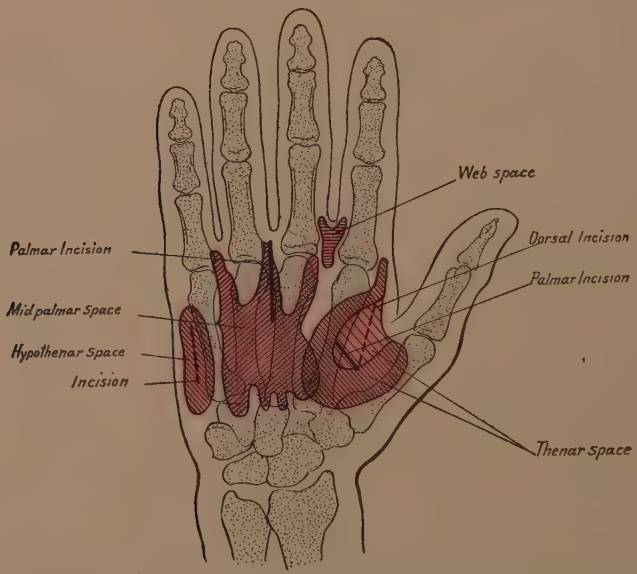


Fig. 39.—Fascial spaces of palm and lines of incision (in black), to expose pus therein.

Middle palmar space abscesses are preferably reached by an incision along the little, ring, or middle finger lumbrical canals which lead to this

space. The choice of the canal of entrance will depend on which area shows the maximum involvement, but usually an opening in the space between the ring and middle finger gives best drainage. The diagram shows best the site of the incision. Roughly speaking, the incision is prolonged a thumb's breadth and a half up into the palm; then an artery clamp is pushed under the palmar tendons, the blades are opened, and the pus escapes. Drainage is maintained by rubber tissue or bands or by gauze soaked in vaselin.

If, in addition, the *thenar space* is involved, then the forceps are introduced as above, and pushed through the thin wall between the palmar and thenar spaces at the proximal end, the point coming out on the back of the hand between the thumb and index metacarpals. Through-and-through drainage then is inserted.

If the *middle palmar* and *subaponeurotic spaces* are involved together, then the pus lies always over the interosseous space between the ring and middle fingers. Hence the incision is in this space, the cut being through the palmar aponeurosis where the middle palmar crease crosses the space, and through this the point of the forceps is thrust to the dorsum and rubber drainage inserted. By this procedure the vessels of the palmar arch and the ulnar bursa escape.

Fig. 40.—"Collar-button" or web-space abscess.

Thenar space abscess requires early drainage, and this is easily provided by an incision on the *dorsum* to the radial side of the middle of the index metacarpal, and through this a forceps is passed to the palm and a rubber drain inserted, so that it lies across the flexor surface of the index metacarpal. This incision does away with any palmar opening and subsequent scar thereon.

DORSAL SUBAPONEUROTIC SPACE ABSCESSES

The incision is on the dorsum in the intermetacarpal spaces, inasmuch as the tendons overlie the metacarpals except in the little finger. If the infection has spread upward under the annular ligament, the pus then will lie upon the pronator quadratus and under the flexor profundus tendons, and the attack then is best made by lateral incisions about 2 inches above the respective styloids, as already indicated.

HYPOTHENAR SPACE ABSCESSES

These are always localized and well walled off, and can be reached by simple incision over the maximum site of pain or fluctuation.

After-treatment in these fascial space abscesses resembles that of the other infections.

Hot saline or boric dressings are used for a few days, and drainage is removed as soon as possible. Wet dressings macerate the parts and cannot be satisfactorily employed after three or four days, and then oiled or dry gauze is substituted. The part is kept at rest until pain and spread of infection disappears, and then passive motion should begin; ordinarily some motion should be performed on the third or fourth day.

CHAPTER II

CONTUSIONS

A contusion or **bruise** is the subcutaneous rupture of small blood-vessels due to direct or indirect violence. Blows and falls are the common producing causes, and the richer and more superficial the blood-supply, the earlier the external manifestations.

Symptoms.—*Pain*, *swelling*, and *discoloration* are common to all, and these vary, depending upon the source and site of the injury, and to some extent upon individual susceptibility, as some persons have "softer skins" than others.

Pain occurs at once, and is due to injury to the nerve-endings and later to pressure from effusion. At first the pain may be numbing or cause tingling or pressure sensations, or it may become very acute at once. Later the bruised part may throb, pulsate, tingle, or evince more or less "dull pain." Some tissues when bruised cause more pain than others, the testicle, finger-tip, and knee margins being exceedingly sensitive. The more circumscribed the impact, the greater the pain, as a rule.

Swelling appears within a very short time, due to effusion of blood or lymph and the interference with circulation. The extent of swelling is dependent upon the source and site of the contusion and to a certain degree also upon treatment. Superficial bruises cause instant swelling; deeper bruises may show no such sign for several hours, especially after indirect or transmitted violence.

Discoloration is due to hemorrhage and effusion, and in amount depends upon the source and site of the contusion, and to some degree also upon personal tissue resistance. The site, depth, and extent of the effusion determines its color, and the nearer the surface, the earlier and more red will it appear. Deeper hemorrhages are likely to cause bluish or black mottlings. The discoloration may be circumscribed or diffused and it may follow muscle or fascial planes or broadly trickle over wide areas.

If circumscribed and more or less encapsulated, it is known as a *hematoma*, and this may vary as between a "blood blister" due to a pinched finger and a huge "bump on the head" from a severe blow.

Diffused discoloration is called *ecchymosis* or *suggillation*, and is characterized by mottling of relatively large areas.

The earlier the appearance of discoloration, the more superficial the bruising; but the extent is no adequate guage of the size of the ruptured blood-vessels nor of the amount of escaped blood, for a tiny ruptured vessel in one area may cause more discoloration than a large ruptured vessel in another more compact region. The typical example of ecchymosis is a "black eye"; and the commonest site of a hematoma is the scalp. If the discoloration of a part is due to congestion (intravascular in origin) it will temporarily disappear on pressure; if due to ecchymosis (extravascular in origin) it will not disappear on pressure.

After a time the tinge of discoloration fades from black or deep blue to violet, to yellow, and then to normal, and in some regions this fading process may extend over many weeks or even months.

Hematomata usually spontaneously subside and less often become infected and end as abscesses. Occasionally they undergo cystic or fibroid changes, and when the latter occurs they may simulate certain types of new growth; still more rarely they may result in *myositis ossificans*, a tumorous formation containing bone. (See p. 422.)

Treatment.—This may be summed up by the terms **rest, pressure, lotions,** and **massage.**

Rest is provided by keeping the part quiet in an easy position, supported if necessary by a dressing wet in the chosen lotion and perhaps held also by a bandage or small splint.

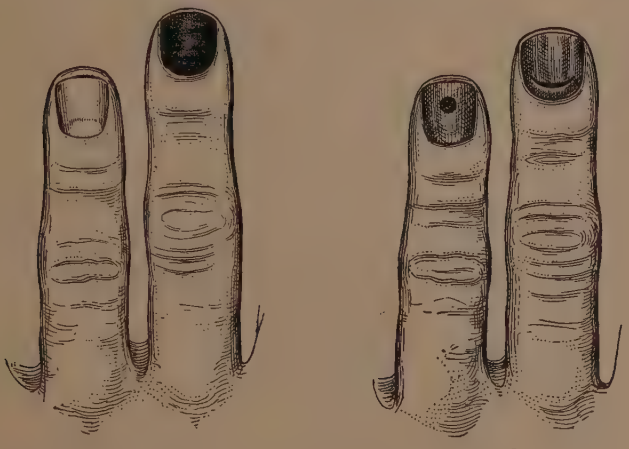
Pressure is most useful in hematoma formation, and this is best provided by compresses, bandaging, or adhesive strapping.

Lotions should be cold, and compresses of ice-water are as good as any; alcohol or lead and opium and a host of others may also be used. Some persons prefer hot applications, but in the early stages cold is more valuable. An ice-bag is often an excellent aid.

Massage is advisable for pain and it also dissipates ecchymosis and promotes circulation.

Hematoma formation usually subsides under continuous pressure, and too early aspiration or incision often converts a simple into a complicated affair, and I have seen several cases where meddlesome and unaseptic interference has done permanent damage. Caution is especially necessary in dealing with hematomata near joints and along the shin; but, wherever they may be, no aspirating or incision should be made without strict attention to surgical cleanliness. The most dependent part of the hematoma is to be attacked under these operative necessities, and the aspirating needle or small knife enters at the

junction between the swelling and the sound skin and not at the summit of the swelling. If the contents can be wholly removed it is needless and harmful to inject irritants into the hematoma zone, for as a rule any sac requiring irritating injections will sooner or later demand complete exsection. If an organized clot or cyst forms, obviously the treatment is modified to include full dissection.



a *b*

Fig. 41.—*a*, Hematoma of the nail; *b*, decompression and incision methods for removal of blood.

Finger-nail bruises with hematoma formation (subungual hematoma) are usually very painful, and numbers of them subsequently lead to infection, and for that reason early incision through the base of the nail is an appropriate form of treatment, as the nail will be ultimately cast off, as a rule. The involved part of the nail may also be trephined instead of incised, so that the "congealed" blood may escape (Fig. 41, *b*).

Contusions of special regions are elsewhere considered.

CHAPTER III

SHOCK

THIS is a temporary depression or collapse of the vital forces due to psychical or physical trauma, in which alteration of blood-pressure is a cardinal feature due to vasomotor inhibition or exhaustion.

Causes.—The term "collapse" is sometimes used for cases due to non-surgical causes; and the terms "surgical shock," "ordinary shock," and "psychic shock" are also used by others with the same etiologic distinction in view.

Crile, however, states that shock is due to inhibition of the vasomotor centers, and collapse ensues upon exhaustion of them; hence the former occurs immediately and the latter gradually.

To some extent every sort of psychical or physical violence is attended by shock, but that inflicted by injuries to the abdominal and cranial cavity is usually of a more severe grade than when elsewhere imposed. Crushes of limbs are also frequently associated with high grades of shock, as is any injury accompanied by marked hemorrhage. Every serious injury, however, is not necessarily attended by severe shock, as it is a matter of common experience that some very trivial physical injuries are accompanied by much psychical shock.

During excitement, as in anger, battle, work, or play, shock may be very slight, owing to mental pre-occupation, even though the injury is essentially of very severe physical type.

Occasionally shock does not appear after an accident until the patient becomes conscious of an injury by the comment of an onlooker, the trickling of blood, or the sight of a wound.

Any injury capable of blocking or crushing the peripheral nerves or trunks is less likely to produce shock than if the nerve-supply is suddenly subjected to other forms of damage. Crile has shown that shock can be almost entirely abolished if the nerves are injected or blocked prior to traumatizing a part.

The vasomotor tone or pressure of the blood-vessels is maintained by a complex nervous mechanism determining their dilation (vasodilators) and contraction (vasocontractors), and it is known that the determining element of shock is a lowering of blood-pressure and a consequent deficient blood-supply to the parts affected. For this reason, injury to the abdominal, thoracic, and cerebral cavities are

likely to be shock productive because of their highly organized and intimate relationship to the vasomotor nervous mechanism.

From a practical standpoint surgical shock often indicates hemorrhage even though it may not be manifest externally.

Symptoms.—Obviously, there are all grades, and these are usually spoken of as *mild*, *moderate*, and *severe*, the particular type being determined by the extent and duration of the respective manifestations.

We speak also of *primary* or *immediate*, and *secondary*, *late*, or *delayed* shock.

A typical case presents rather a characteristic appearance, in that the patient immediately after the accident is unconscious or nearly so; the surface of the body is pale, cold, and sweaty; the expression is anxious, the eyes are shut or widely open; the pupils are dull, usually dilated, and slowly responsive; respiration is shallow and feeble and often intermittently sighing; the pulse is weak, compressible, and often irregular, and may be slow or rapid; if arousable, mental confusion or torpidity is the rule; sometimes the sphincters are relaxed and nausea and vomiting may occur; the temperature is subnormal or slightly elevated at first. After some minutes, or later, these patients gradually become aroused, their color returns, the mind clears, the pulse and respiration strengthen, and they recover.

Other much more severe grades may remain in a state of mental and physical depression or mental torpor for many hours and even die in deepening coma from shock alone, although death from this source independently is quite rare and should not be accepted as a sole cause in the absence of an autopsy.

In some instances a condition of apathy is replaced by one of irregular activity of a somewhat delirious type, this occurring especially with head injuries and in alcoholics; this is the so-called erethistic as distinguished from the apathetic or ordinary form, and it is very closely allied to traumatic delirium.

Thus, all varieties are met with, from that of the *mild* grade, showing pallor, giddiness, yawning, nausea, and fainting, to that of a *moderate* grade, with the preceding accentuated together with cardiorespiratory changes and mental apathy, and thus on to a *severe* grade, with actual abeyance of vital functions.

Local shock occurs notably from bullet wounds in which the part injured becomes paralyzed as to motion and sensation, and may so remain for many hours or even days; it is a very rare form in civil practice.

Secondary or *late shock* generally is an indication of bleeding or sepsis, and usually appears within the first forty-eight hours after an

accident which perhaps up to that time had been unattended with serious symptoms. Sometimes it is a postoperative manifestation from the anesthetic or operative trauma causing extension of infection or bleeding.

Shock and *hemorrhage* often coexist, especially in that class of accident to which the diagnosis "internal injuries" (or "concealed hemorrhage") is given. This notably occurs in abdominal and cerebral injuries, and the differentiation is often very difficult and always important, as the treatment depends much on whether the case is one of shock **solely from hemorrhage** or shock from physical and psychic causes **with hemorrhage** also. These patients are usually in a marked

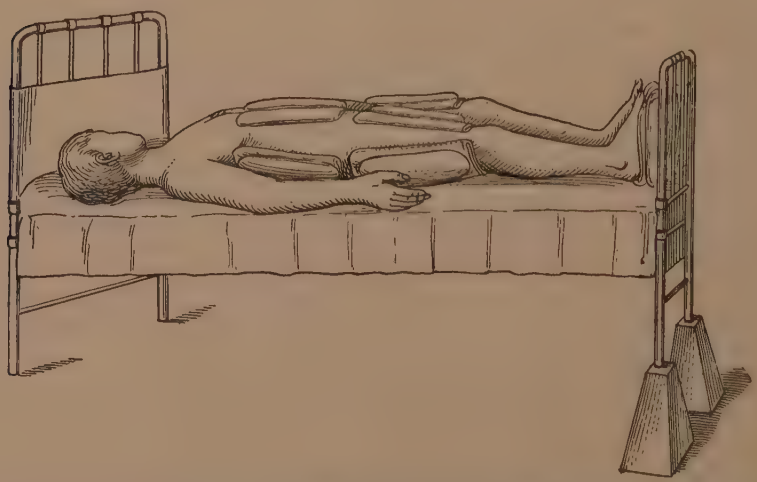


Fig. 42.—Hot-water bags or bottles applied for shock. Note protection of the skin by pads and elevation of the foot of the bed.

state of shock when first seen, and the abdominal cases frequently are tympanitic, tender, and show marked localized or general tenderness or rigidity, and the diagnosis of intra-abdominal hemorrhage and probable torn viscus is entertained.

In many instances it is injudicious to operate even if the indications were clearer, and, accordingly, the shock alone is treated and the patient watched. If improvement is reasonably prompt, and especially if the condition began at the time of the accident, the condition is probably shock in the main; if, however, the reverse pertains, and if the blood-picture is one of acute anemia with a low hemoglobin percentage and a progressive onset of symptoms, then the element of bleeding must be given greater consideration.

Shock patients get better, while bleeding patients often get worse during treatment and lapse of time.

Treatment.—The associated injuries are given adequate, but not too prolonged treatment, and every effort is made to handle exposed or damaged parts with all due gentleness, and if much time will be necessary for temporary repairs, it may be wisest to use an anesthetic. Theoretically, anesthesia may induce shock, but practically the reverse is true, and many times I have had the patient's pulse and general

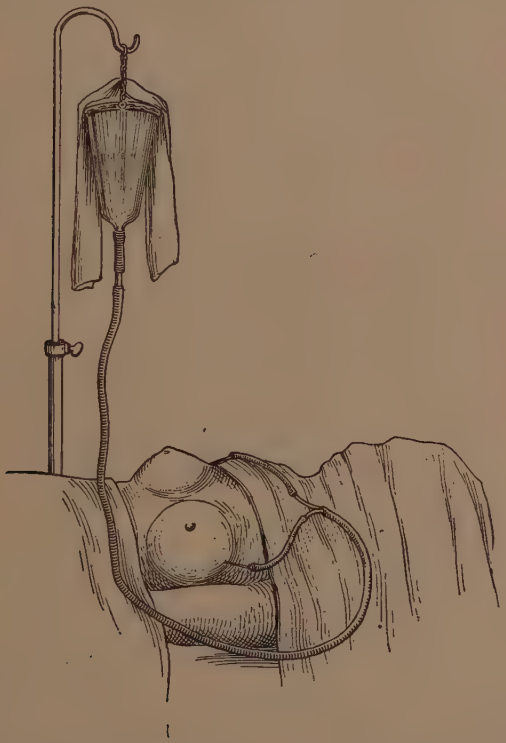


Fig. 43.—Subpectoral infusion of normal saline, glucose (5 per cent.), or other solutions for shock, hemorrhage, acidemia, anuria, or other conditions.

condition improve when fully narcotized. Obviously, no postponable operative work should be undertaken until shock is passed. A hypodermic of morphin to a conscious patient is a prime requisite. The foot of the bed is raised and hot applications are applied to the protected surface of the body (Fig. 42). Adrenalin is one of the best cardiac stimulants for subcutaneous use. Camphor and ether act promptly. Salt solution by rectum, with or without adrenalin, is another of the most efficient means at hand. It may be used by the so-called "drop method" of Murphy, in which 30 or more drops per minute are al-

lowed to enter the rectum by a small tube, and this is continued until the volume of the pulse is satisfactory. Plain water seems to act just as well as normal salt solution. Another and more usual method is to slowly introduce into the rectum 6 to 8 ounces of saline or plain water with 2 or more ounces of whisky, this to be repeated in one-half hour or less, if needed. Saline solution may also be introduced under the skin by a needle piercing the outer side of the upper thigh or the mammary region (hypodermoclysis—Fig. 43). In very severe cases a vein at the elbow is opened and salt solution administered intravenously (saline infusion—Fig. 44). Comatose patients will absorb and benefit from adrenalin in a watery or saline solution (1 : 100) dropped every few seconds on the base of the tongue. Transfusion is very rarely applicable, but when feasible the blood can be most readily introduced

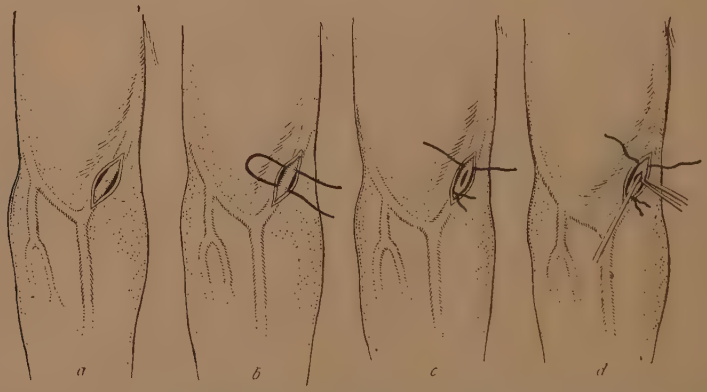


Fig. 44.—Opening vein at bend of elbow for infusion: *a*, Vein exposed; *b*, catgut loop passed under vein; *c*, distal end of vein ligated; *d*, infusion needle introduced and about to be fastened by catgut ligature.

as in an infusion, using 50 c.c. of a 2 per cent. solution of sodium citrate to each 500 c.c. of donor's blood; this is the so-called "citrated blood" method. The citrate and the blood admixture can be kept several days without deterioration. Pituitrin has recently been advocated and the dosage is 1 c.c. hypodermically; it acts well in many instances.

Mild cases get well by simply using rest and elevation, hot applications, and small doses of aromatic spirits of ammonia or whisky.

Prognosis.—Ordinary cases recover within a few days, and the outlook is then guaged by that of the associated injuries.

Severe cases take a longer time, and if hemorrhage is coincident, the resulting anemia may be quite depleting. Fatal cases are generally associated with severe injuries, and death is usually due to a combination of causes rather than to shock alone.

CHAPTER IV

INJURIES OF THE JOINTS

The Blood-supply In and Around the Joints[1]

The accompanying series of skiagrams (Figs. 45–54), showing the blood-supply in and around many of the important joints, were made in the *x*-Ray Department of Dr. John B. Murphy's Clinic at Mercy Hospital, Chicago, by Dr. George W. Hochrein. The idea of these skiagrams suggested by Dr. Murphy had for its object the accurate determination of the blood-supply and its relations to the various joints, and are a great aid in determining the position of the flap pedicle used in arthroplasties. The whole series comprises a unique and valuable collection in applied anatomy, and is used at the clinics of Dr. Murphy in his work on the bones and joints.

Wounds

They are mainly due to penetration of the joint by cutting instruments, missiles, sharp fragments, bullets, compound fractures, and infected contusions.

Symptoms.—The signs depend upon the manner and the site of the injury and the presence or absence of infection.

In *non-infected wounds*, the signs of penetration are mainly based on the escape of glairy synovial fluid, with evidences of synovitis or joint inflammation, together with such contusion remnants as diffused or localized discoloration.

In *infected wounds*, the above signs exist, plus the redness, swelling, heat, localized pain, and disturbed function so universally indicative of inflammation or cellulitis. An initial chill may denote the onset of the trouble and elevation of pulse and temperature are always present. Later signs are those of a purulent synovitis with the escape of pus from the site of joint entry, and by this time constitutional signs of a more or less septic type are well advanced.

[1] The illustrations with descriptive legends were taken from "Surgical Clinics of Dr. John B. Murphy," Volume II, No. 4, August, 1913.

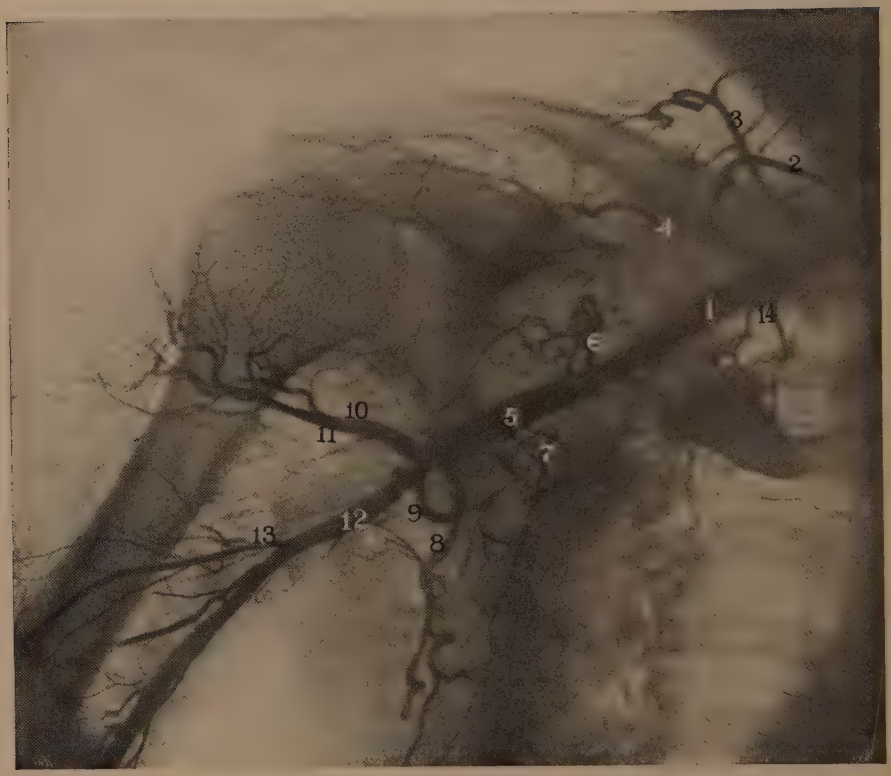


Fig. 45.—The blood-supply in and around the left shoulder-joint. 1, Subclavian artery (A. subclavia): Thyroid axis (truncus thyreocervicalis). Not visible; 3, superficial cervical artery (A. cervicalis superficialis); 4, suprascapular artery (A. transversa scapulæ); 2, transverse cervical artery (A. transversa colli). 5, Axillary artery (A. axillaris): 14, Acromiothoracic artery (A. thoraco-acromialis); 7, long thoracic artery (A. thoracalis lateralis); 8, subscapular artery (A. subscapularis); 9, dorsalis scapulæ artery (A. circumflexa scapulæ); 10, anterior circumflex artery (A. circumflexa humeri anterior); 11, posterior circumflex artery (A. circumflexa humeri posterior). 12, Brachial artery (A. brachialis): 13, Superior profunda artery (A. profunda brachii). The dark area over the chest wall was caused by an extravasation of injection fluid under cover of the pectoralis major, from pectoral branches of the acromiothoracic artery. 6, Anastomosis on the dorsum of the scapula. The anastomoses about the acromion and about the surgical neck of the humerus can be clearly distinguished. (Surgical Clinics of John B. Murphy.)

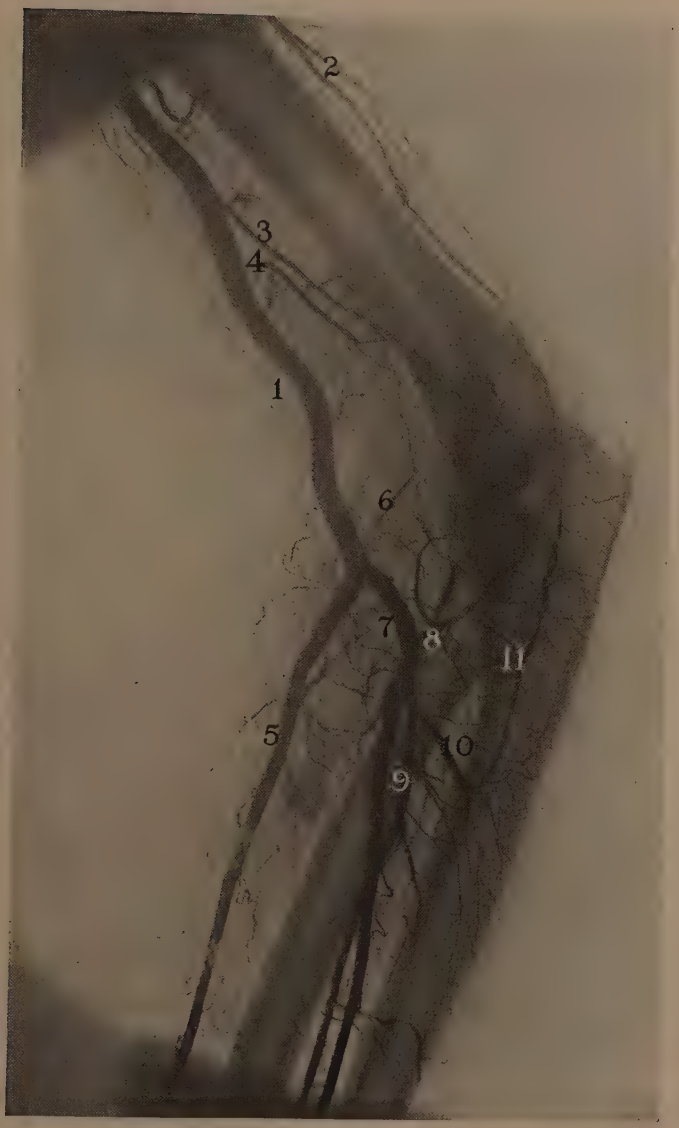


Fig. 46.—The blood-supply in and around the right elbow-joint (lateral view). 1, Brachial artery (A. brachialis): 2, Superior profunda artery (A. profunda brachii); 3, inferior profunda artery (A. collateralis ulnaris superior); 4, anastomotica magna artery (A. collateralis ulnaris inferior). 5, Radial artery (A. radialis): 6, Radial recurrent artery (A. recurrens radialis). 7, Ulnar artery (A. ulnaris): 8, Anterior and posterior ulnar recurrent arteries (Aa. recurrentes ulnares), by common origin—common interosseous artery (A. interossea communis); 9, anterior interosseous artery (A. interossea volaris); 10, posterior interosseous artery (A. interossea dorsalis); 11, interosseous recurrent artery (A. interossea recurrens). (Surgical Clinics of John B. Murphy.)

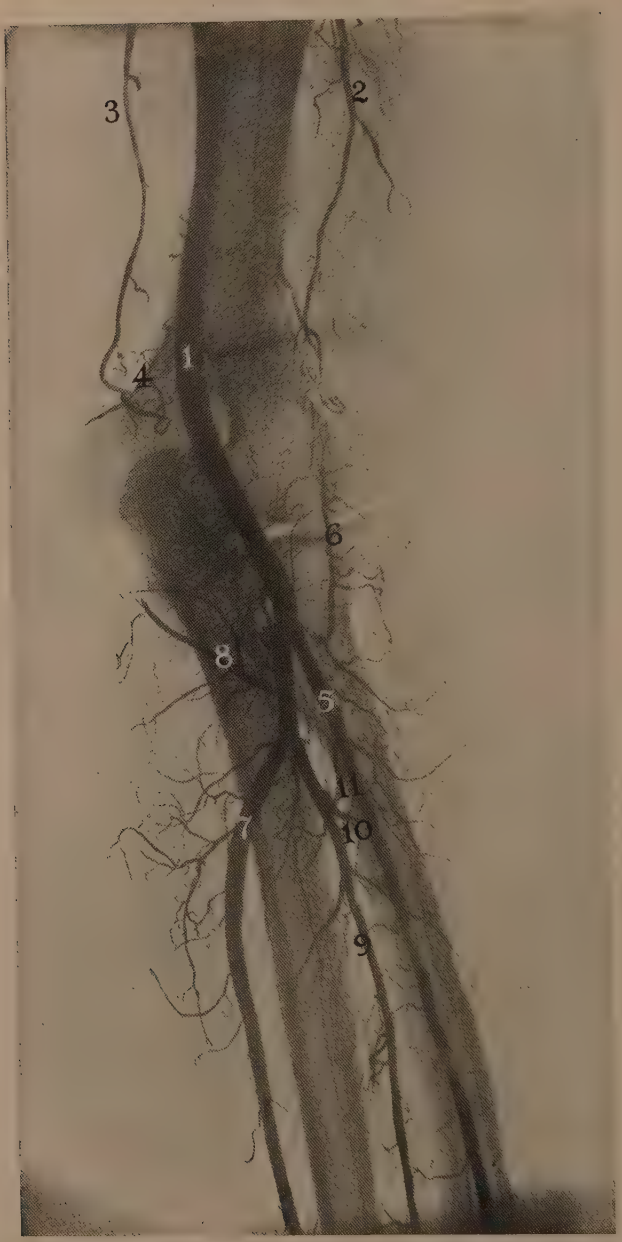


Fig. 47.—The blood-supply in and around the right elbow-joint (dorsovolar view). 1, Brachial artery (A. brachialis): 2, Superior profunda artery (A. profunda brachii); 3, inferior profunda artery (A. collateralis ulnaris superior); 4, anastomotica magna artery (A. collateralis ulnaris inferior). 5, Radial artery (A. radialis): 6, Radial recurrent artery (A. recurrens radialis). 7, Ulnar artery (A. ulnaris): 8, Anterior and posterior ulnar recurrent arteries (Aa. recurrentes ulnares), by common origin—common interosseous artery (A. interossea communis); 9, anterior interosseous artery (A. interossea volaris); 10, posterior interosseous artery (A. interossea dorsalis); interosseous recurrent artery (A. interossea recurrens). (Surgical Clinics of John B. Murphy.)

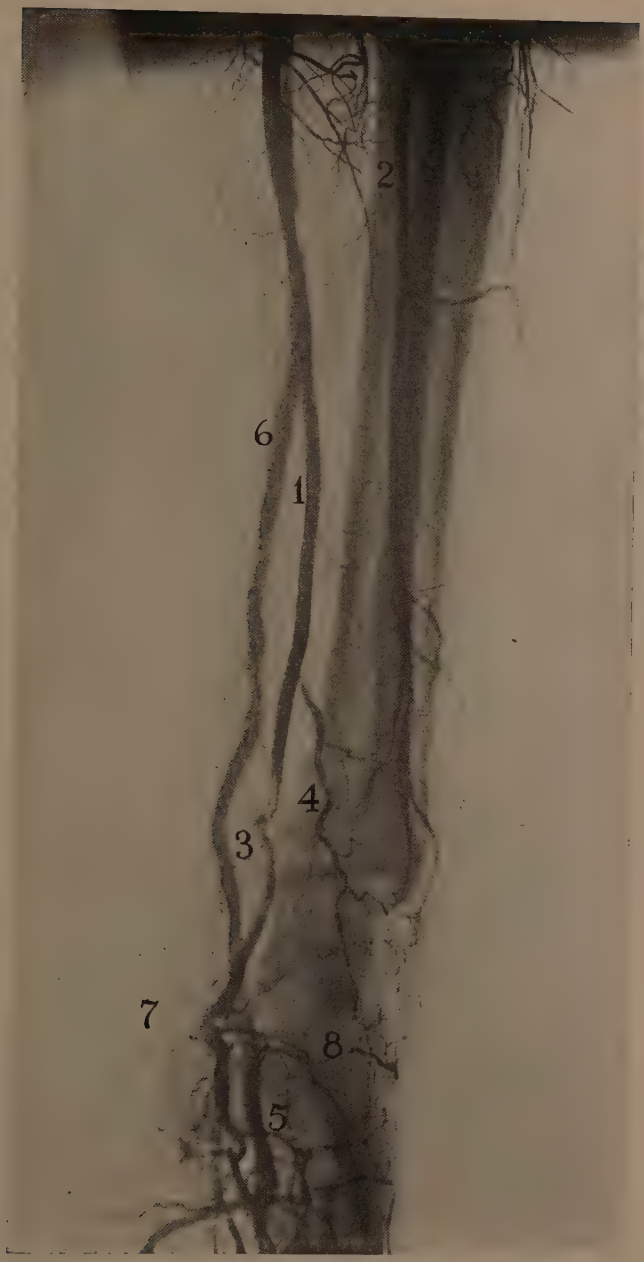


Fig. 48.—The blood-supply in and around the right forearm (lateral view). 1, Ulnar artery (A. ulnaris): 2, Anterior interosseous artery (A. interossea volaris); 3, anterior ulnar carpal artery (ramus carpeus volaris); 4, posterior ulnar carpal artery (ramus carpeus dorsalis); 5, deep palmar artery (ramus volaris profundus). 6, Radial artery (A. radialis): 7, Superficial volar artery (ramus volaris superficialis); 8, posterior radial carpal artery (ramus carpeus dorsalis). (Surgical Clinics of John B. Murphy.)

Fig. 49.—The blood-supply in and around the left forearm and hand. 1, Ulnar artery (A. ulnaris): 2, Anterior interosseous artery (A. interossea volaris); 3, posterior interosseous artery (A. interossea dorsalis); 4, posterior ulnar carpal artery (ramus carpeus dorsalis); 5, deep palmar artery (ramus volaris profundus); 6, superficial palmar arch (arcus volaris superficialis). 7, Radial artery (A. radialis): 8, Anterior radial carpal artery (ramus carpeus volaris); 9, superficial volar artery (ramus volaris superficialis); 10, posterior radial carpal artery (ramus carpus dorsalis); 11, dorsalis pollicis artery (ramus dorsalis pollicis); 12, dorsalis indicis artery (ramus dorsalis indicis); 13, first volar metacarpal artery (A. metacarpea volaris I), dividing into the princeps pollicis artery (A. princeps pollicis) and the radialis indicis artery (A. volaris indicis radialis); 14, deep palmar arch (Arcus volaris profundus). (Surgical Clinics of John B. Murphy.)

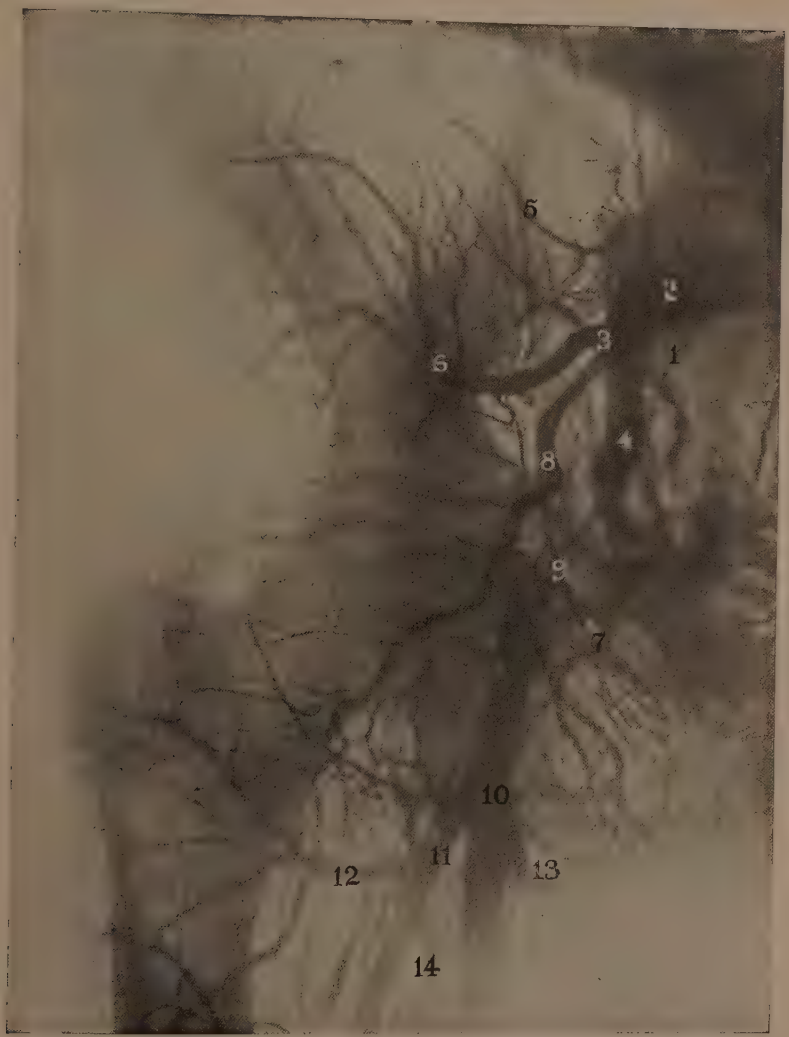


Fig. 50.—The blood-supply in and around the left hip-joint. 1, Spermatic artery (A. spermatica interna); 2, common iliac artery (A. iliaca communis). 3, Internal iliac artery (A. hypogastrica): 5, Iliolumbar artery (A. iliolumbalis); 6, gluteal artery (A. glutæa superior); 7, obturator artery (A. obturatoria); 8, sciatic artery (A. glutæa inferior); 9, internal pudic artery (A. pudenda interna). 4, External iliac artery (A. iliaca externa). 10, Femoral artery (A. femoralis): 11, Deep femoral artery (A. profunda femoris); 12, external circumflex artery (A. circumflexa femoris lateralis); 13, internal circumflex artery (A. circumflexa femoris medialis); 14, first perforating artery (A. perforans prima). (Surgical Clinics of John B. Murphy.)

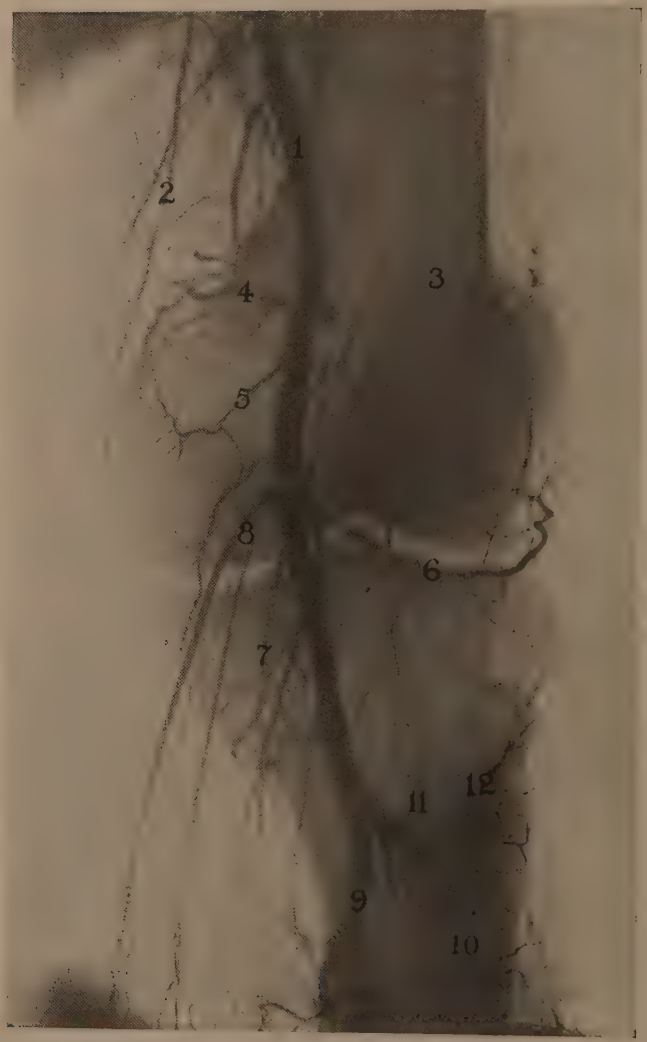


Fig. 51.—The blood-supply in and around the right knee-joint (anteroposterior view). 2, Anastomotica magna artery (A. genu suprema), from deep femoral. 1, Popliteal artery (A. poplitea): 3, External superior articular artery (A. genu superior lateralis); 4, internal superior articular artery (A. genu superior medialis); 5, azygos articular artery (A. genu media); 6, external inferior articular artery (A. genu inferior lateralis); 7, internal inferior articular artery (A. genu inferior medialis); 8, sural arteries (Aa. surales). 9, Posterior tibial artery (A. tibialis posterior). 10, Anterior tibial artery (A. tibialis anterior): 11, Posterior tibial recurrent artery (A. recurrens tibialis posterior); 12, anterior tibial recurrent artery (A. recurrens tibialis anterior). (Surgical Clinics of John B. Murphy.)

Fig. 52.—The blood-supply in and around the right knee-joint (lateral view). 2, Anastomotica magna artery (A. genu suprema), from deep femoral. 1, Popliteal artery (A. poplitea): 3, External superior articular artery (A. genu superior lateralis); 4, internal superior articular artery (A. genu superior medialis); 6, external inferior articular artery (A. genu inferior lateralis); 7, internal inferior articular artery (A. genu inferior medialis); 8, sural arteries (Aa. surales). 9, Posterior tibial artery (A. tibialis posterior). 10, Anterior tibial artery (A. tibialis anterior): 11, Posterior tibial recurrent artery (A. recurrens tibialis posterior); 12, anterior tibial recurrent artery (A. recurrens tibialis anterior). (Surgical Clinics of John B. Murphy.)

Fig. 53.—The blood-supply in and around the right ankle-joint. 1, Posterior tibial artery (A. tibialis posterior): 2, Peroneal artery (A. peronæa); 3, communicating artery (ramus communicans); 4, anterior peroneal artery (ramus perforans); 5, posterior peroneal artery (A. malleolaris posterior lateralis); 6, communicating artery, joining termination of peroneal artery and posterior tibial artery. 7, External plantar artery (A. plantaris lateralis); 8, internal plantar artery (A. plantaris medialis); 10, anterior tibial artery (A. tibialis anterior). 12, Dorsalis pedis artery (A. dorsalis pedis): 11, External tarsal artery (A. tarsea lateralis). (Surgical Clinics of John B. Murphy.)

Fig. 54.—The blood-supply in and around the right foot. 1, Posterior tibial artery (A. tibialis posterior): 2, Peroneal artery (A. peronæa); 3, communicating artery (R. communicans), connecting posterior tibial and peroneal arteries; 4, anterior peroneal artery (R. perforans); 5, posterior peroneal artery (A. malleolaris posterior lateralis); 6, internal malleolar artery (A. malleolaris posterior medialis); 7, internal calcaneal arteries (rami calcanei medialis). 8, External plantar artery (A. plantaris lateralis): 9, Calcaneal arteries (rami calcanei); 10, plantar arch, giving off the plantar interosseous arteries (Aa. metatarseæ plantares). 11, Internal plantar artery (A. plantaris medialis), dividing into two branches at the anterior border of the calcaneus. 12, Anterior tibial artery (A. tibialis anterior): 13, Internal malleolar artery (A. malleolaris anterior medialis); 14, external malleolar artery (A. malleolaris anterior lateralis). 15, Dorsalis pedis artery (A. dorsalis pedis): 16, External tarsal artery (A. tarsea lateralis); 17, dorsal anastomosis (rete dorsalis pedis); 18, metatarsal artery (A. arcuata). (Surgical Clinics of John B. Murphy.)

Treatment.—In the *non-infective* variety the essentials are: (1) Disinfection by liberally applying tincture of iodin to the area of and about the wound; (2) application of a dry sterile dressing of gauze and cotton and bandages; (3) placing the part at rest by a splint with the joint in such a position that (*a*) drainage is most efficient, (*b*) the joint is immobilized in the best posture in the event of later inflammation or fixation. The *knee-joint* is most commonly affected, and the limb should be put in the position of extension and held thus by traction (Fig. 55). In the *elbow* and *ankle* the position for splintage should be at a right angle. In the *infective* variety the preliminary liberal use of iodin is made, and drainage should be early provided in the presence of signs of sepsis. If possible this should be through the original wound if it be in a dependent position; otherwise the joint should be widely

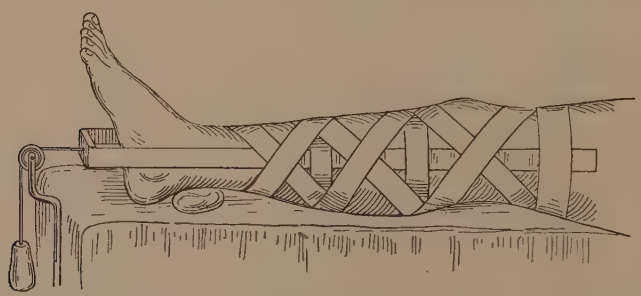


Fig. 55.—Adhesive strapping and weight extension for traction on leg, knee, or lower thigh.

opened at a site where the discharge can be most effectively released (Figs. 56, 57). Any procedure of this sort must be undertaken under the most aseptic precaution, preferably during full anesthesia. Vertical incisions are made lateral to the joint and are placed to permit through-and-through irrigation by saline hot bichlorid solution (1 : 10,000) or iodin water, as the extent of the infection may suggest. Irrigation is unwise unless there is a free vent. No manipulation within the joint should be made unless absolutely indicated. Fenestrated rubber tubing or folded gutta-percha makes the best drainage; whatever is used, two such drains act better than one (Fig. 58). A plentiful moist gauze dressing (saline or iodin water), with cotton and oiled silk and *loose* bandaging is then applied, a splint serving to keep the parts at rest.

Under no circumstances should a doubtful wound about a joint be probed, stitched tightly, or sealed by any form of occlusive dressing.

The dressings should be changed at the end of twenty-four hours, or earlier if the local or systemic signs warrant. If, then, drainage seems inefficient, a long closed artery clamp is to be thrust through the drainage opening and withdrawn with the blades opened. Such a procedure may result in the escape of pent-up pus, and this pocket must then be cared for by a special drain of the rubber tubing or gutta-percha tissue type named. If, despite this, further invasion proceeds, additional incisions must be made wherever demanded in order to forestall the loss of limb or life. If, despite these numerous vertical incisions, the septic process threatens to extend, then the joint must be freed by transverse incisions, exposing the interior to inspection so that the limb can be bent as if on a hinge (Fig. 59). All infected foci are then in sight and pockets of pus and sloughs removed. The joint thus opened is then loosely packed with gauze tapes wrung out of saline, iodin, or bichlorid (1 : 10,000) solution, and the whole enveloped in a huge wet dressing with the joint hinged widely apart and held in that position by a suitable support.

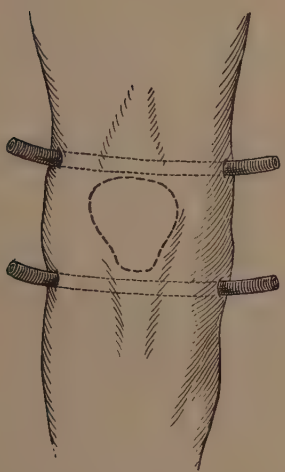


Fig. 56.—Through-and-through rubber tubing drainage of the knee-joint.

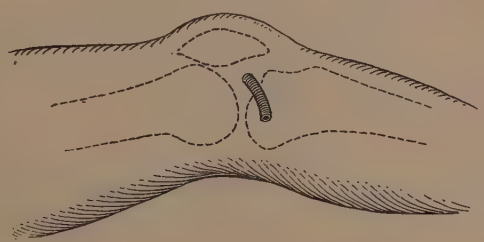


Fig. 57.—Unilateral rubber tubing drainage of the knee-joint.

This type of treatment is most applicable in the knee-joint, which is exposed by severing the patella tendon as well as other soft parts. If the joint thus exposed shows areas of osteomyelitis or extensive cartilage involvement, then the propriety of disarticulation or amputation must be entertained. The wisdom of these last operations depend mainly upon the type of infection and the systemic state of the patient. If the infection is of the streptococcus or some equally rapid and virulent type, further delay is hazardous, even though the systemic condition appears favorable. If the reverse pertains, then further attempts

to save the limb may be made. Many of these cases do better with early resection or amputation than with less active treatment necessitating prolonged attention that may end with persistent sinuses and a joint so distorted as to be practically useless. In the knee-joint especially, early opening of the joint by a transverse incision across the patella tendon and the lateral ligaments often stops the progress of an infection that otherwise would demand amputation of the thigh.

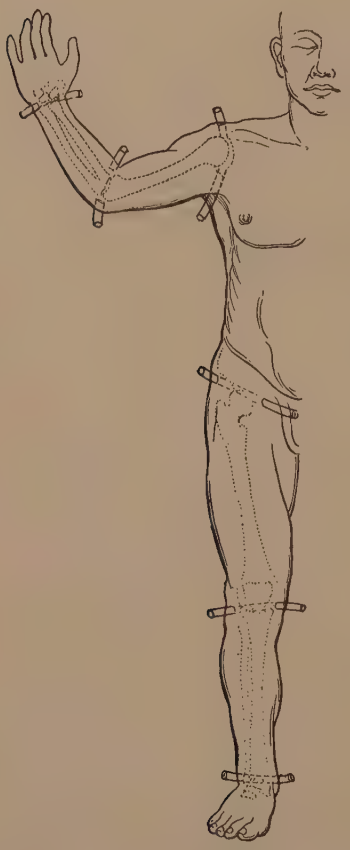


Fig. 58.—Sites for joint drainage by the through-and-through introduction of rubber tubing.

Systemic Treatment.—This is directed to fortifying the patient by appropriate drugs and a concentrated diet. In cases of prolonged sepsis I am a believer in the efficacy of iron, quinin, and strychnin, and

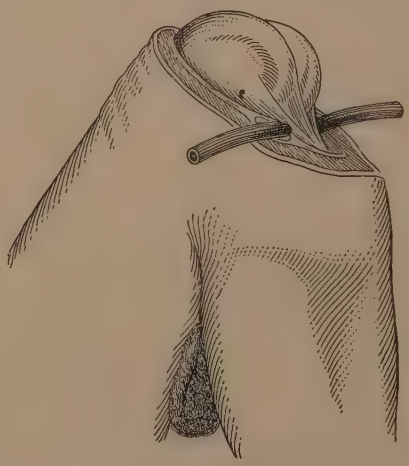


Fig. 59.—Drainage of knee-joint in hyperflexion (Mayo's method).

the judicious use of alcoholics and such anodynes as may be needed to allay pain and provide sleep. In those who habitually use alcohol the early use of bromids and chloral will ward off threatened delirium tremens. If it is possible, these cases of joint infection should be out-of-doors, with the limb exposed to the air and sunlight. I have never seen any especial benefit from continuous irrigations or immersions. Traction to keep joint surfaces apart should be early employed. As soon as practicable, drainage should be withdrawn and the limb re-

stored to a position where function will be best conserved in the event of ankylosis.

When all signs of local inflammation have subsided, massage will be notably effective, and often surprisingly good results will follow it and intelligent active and passive motion. Persistent sinuses do well under forced aspiration by Bier's cup, and the injection of bismuth paste (vaselin and bismuth subnitrate equal parts), introduced by an ordinary syringe with a catheter or other tube, so that the cavity is filled to overflowing with the paste heated to a syrupy consistency.

Many of these cases with persistent stiffness, with or without sinuses, do well under the daily use of Bier's constricting band applied above the affected part. A wide rubber bandage acts best, and it should be applied with the limb elevated and left several hours if (*a*) no pain results and (*b*) if the parts do not become cold or (*c*) too pale or too engorged. In the event of contractures, suitable operations can be contrived to render the joint more functionally active.

Sprains and Strains

A *sprain* is the sudden violent stretching of the soft parts about a joint, and is accompanied by swelling, disturbance of function, and usually by discoloration, and is frequently associated with some tearing of the fibers about the part affected.

A *strain* is practically a lesser degree of the foregoing, and generally proceeds from a less sudden and violent form of violence and in a part where joint excursions are more limited.

Lawn tennis arm is a strain of the pronator radii teres.

The *glass arm* of baseball players is a strain of the long head of the biceps.

Rider's leg is a strain of the adductor of the thigh.

Commonly the ligaments about a joint are the parts involved, but the tendons, synovial membrane, or the soft parts may be alone affected. The condition is one of inflammatory irritation manifested by characteristic signs of varying extent.

Causes.—Ordinarily they are due to indirect violence, as from a sudden twist or undue use of a joint. Exceptionally they follow direct violence, but then it is usually a part of a joint contusion, dislocation, fracture, or other injury.

Symptoms.—These depend upon the nature of the injury, the joint involved, and the individual. Common to all are *swelling*, most

marked over the site of maximum tension and usually of a puffy variety. *Discoloration* is always present, at first of a reddish variety, later becoming bluish or ecchymotic. *Pain* occurs at the instant the joint is moved beyond its normal limits, and may be local to the part chiefly involved or quite general. Sometimes the pain is acute enough to make fainting imminent, and pallor, vomiting, and signs of shock often coexist. In mild forms pain is not complained of until elicited by pressure of the examiner's fingers or induced by joint action. *Impaired function* usually is present to some extent, and may be due to pain, swelling, or stiffness.

Diagnosis is to be made from fracture, dislocation, synovitis, and bursitis.

About the wrist and ankle it is especially needful to be on guard to exclude bony injury, notably that form of fracture termed by some writers "sprain-fracture," by which is meant the so-called "periosteal fracture," in which a small flake of bone is pulled away by a tendon or ligament. In cases of doubt, or in the absence of *x*-ray confirmation, it is wise to regard such an injury as a fracture and treat it accordingly.

Treatment.—To a great extent this depends on the joint affected, the nature and extent of the sprain, and the individual's age and occupation. Two general forms of treatment are applicable, depending upon the foregoing factors.

The *rest treatment* consists in the application of some immobilizing dressing to the joint, such as a padded starch or *light* plaster-of-Paris dressing or adhesive straps after the first twenty-four hours, or when swelling and acute inflammation have subsided under the application of an ice-bag, cold-water dressings, or a lotion of the lead-and-opium type. This immobilizing dressing is allowed to remain until the swelling decreases, as then it becomes loose and of no further support. Usually this is within a week, and it is then replaced by a lighter form of a similar immobilizing dressing, which remains in place a week or ten days longer. Thus, at the end of three weeks this stiff dressing is permanently removed and light massage daily given, to be followed in a few days by deeper and more general massage with passive motion. When these manifestations are well borne, active use of the joint is gradually permitted, the part being supported by a bandage, straps of adhesive, or other removable dressing. At this stage a woven linen mesh bandage is particularly useful because it is elastic, washable, durable, cheap, and much more preferable than the so-called "elastic supporters." The patient may desire to wear some support for several

weeks, and a strap of adhesive plaster or a few turns of a linen mesh bandage will answer for this purpose.

If any stiffness results, alternate douching with hot and cold water ("the Scotch douche"), followed by brisk massaging with hot camphorated oil, will be found effectual. By this form of treatment disability is more or less complete for three weeks and may last six weeks. Thereafter there will be some partial disability lasting two or three weeks longer, during which period the patient is gradually assuming his full duties. Disability is obviously shorter for those who do not require to actively use the damaged joint at work.

The *active treatment* method depends for its success upon the early use of massage and moderate use, in an effort to promote prompt absorption of the exudate and thus prevent adhesions or stiffness. Hence, at the onset the joint is immersed in very hot water or hot boric solution for five to thirty minutes and then massaged for five to fifteen minutes with light upward strokes. The limb is then elevated, and straps of adhesive plaster are applied so that they overlap at right angles and completely encircle the joint to well beyond its margins. After this moderate increasing use of the part is encouraged. If the adhesive becomes loose, it is tightened or otherwise reinforced so that it constantly affords snug pressure. *Under no circumstances must the adhesive so encircle the joint as to constrict circulation.*

After the pain and swelling has to a considerable degree subsided it is permissible to remove the adhesive plaster and use douching twice or more daily with hot and cold water, followed by massage with warm camphorated oil. From this time onward the treatment does not differ from that outlined in the foregoing method.

Needless to say, care should be observed for a time in the use of the joint and it should be favored whenever possible.

Chronic Sprains.—Many persons have a "sprain tendency" due to the natural joint relaxation, previous joint injury or disease, or to clumsiness incident to structural causes or improper footgear. Such cases are frequent among those having unilateral or bilateral flat-feet or other pedal deformities. In a joint of this character there is generally more or less preliminary puffiness or actual swelling, with or without pain and tenderness on use or manipulation.

Symptoms.—These resemble those of the acute variety in the main, except that the manifestations are likely to be in exaggerated form, although the pain is frequently less marked.

Treatment.—Preventive measures are most important, and those with "weak joints" should guard themselves against recurrence by

joint supporters and proper shoes. Fat people who wear low shoes with high heels are frequent victims of their own vanity. Those operating gasolene engines often need special wrist supporters when cranking automobiles, motor-boats, or other gas engines. These recurrent cases do best when placed in a well-padded starch or light plaster-of-Paris dressing immediately, but these are instantly split if swelling or other signs of obstructed circulation appear. Such a dressing will get loose in a few days and can be replaced by a similar dressing to be worn a week longer. By the end of a fortnight an adhesive plaster strapping can be applied and use of the part gradually encouraged. When pain on moderate use ceases this dressing can be replaced by some form of support that should be used long enough to permit the joint to regain its normal tone. Athletes or others who are subjected to occasional rather severe use of such a joint ought to habitually wear some form of elastic or leather brace device.

SPRAINS OF SPECIAL JOINTS

The *ankle*, *knee*, *wrist*, *elbow*, *shoulder*, and *back*, in the order named, are most subject to sprains.

Ankle Sprain

Causes.—A sudden misstep, as in walking on an uneven surface with a "turning of the ankle"; or a similar result in stepping from one level to another, as off a curbing or stairway, or a fall on the foot. Generally the external part of the joint is most affected, as the ankle usually bends inward. Frequently the central part of the joint is coincidentally involved with either of the lateral portions.

Treatment.—If seen within a few hours the interlacing adhesive plaster dressing popularized by Gibney acts best for the average case (Fig. 60, *A*, *B*, *C*). In applying this the foot is bent beyond a right angle and sharply inverted and held in that position while 1-inch wide zinc oxid ("Z. O.") adhesive is applied. This posture can be maintained by the patient when no aid is at hand if a bandage is tied to the big toe and the latter is pulled upward while the relaxed foot rests with the weight on the calf of the leg. The first strap begins about 6 inches above the external ankle, passes down in the groove behind the external malleolus under the tip of the heel, and up in the groove back of the inner malleolus to the inner side of leg, a few inches higher or lower than the place of starting. The second strap begins below the instep, at the base of the middle toe, and passes back just above the level of the

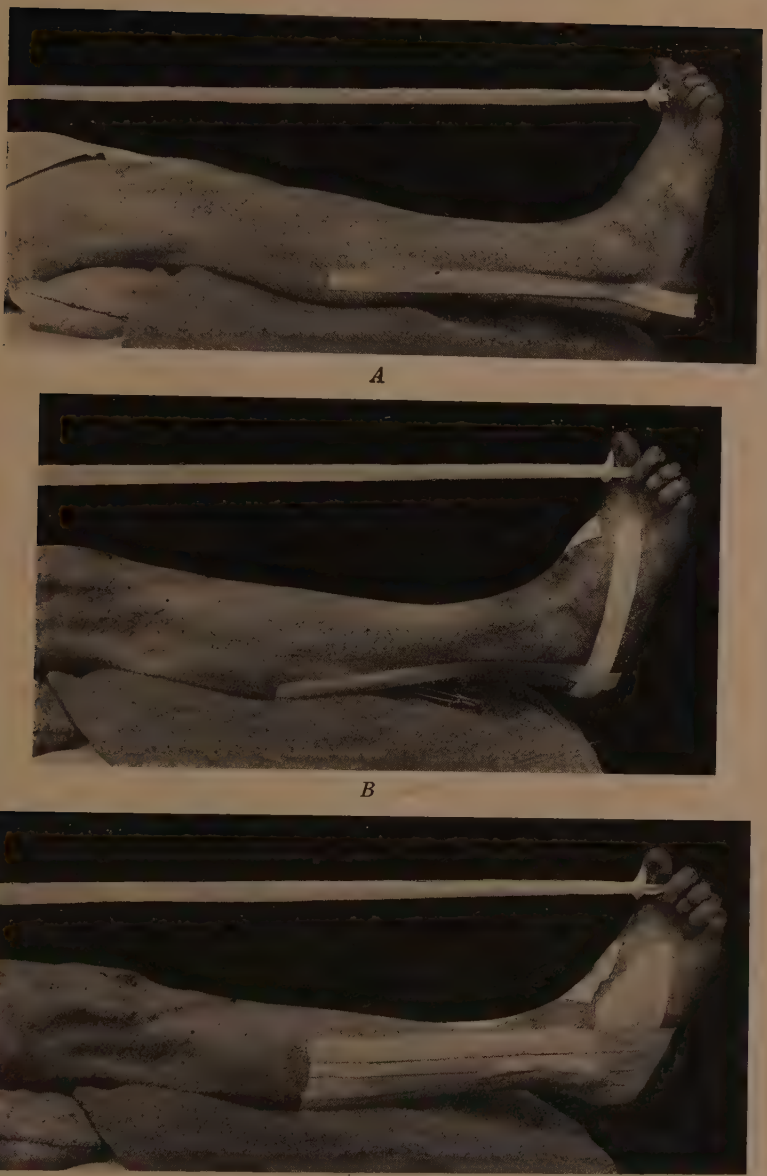


Fig. 60.—Adhesive plaster dressing (basket weave) for ankle injuries. *A*, First vertical strap applied behind malleoli level. Note method of holding foot in flexed inversion by a bandage around toe held by patient. *B*, First transverse strap applied close to sole. *C*, Successive layers applied. Note channel for circulation purposely left along dorsum. As many more layers as seem necessary may be applied.

outer sole and around the tip of the heel under the external malleolus and along the inner sole to within $\frac{1}{2}$ inch of the starting-point. The

third strap overlaps the first by half its width. The fourth strap likewise overlaps the second, and so on, until the whole joint is enclosed in the manner indicated in the diagrams. Space for circulation must be left ½ inch wide down the front of the leg and foot. A snug bandage (such as the non-slip, shown in Fig. 61–63) will cause the straps to firmly shape themselves, and the foot can then be elevated on a pillow and an ice-bag strapped over the joint for several hours. After from three to ten days the straps get loose and they can be wholly replaced or their margins cut and tightened by several 8-shaped pieces of adhesive or a

Fig. 61.—Applying the non-slip bandage. One end held free.

linen mesh or gauze bandage. After two or three weeks a linen mesh or other more or less elastic supporter may be comfortable. Preliminary shaving of the part will make the plaster mold better and aid in its removal. The use of gasolene, benzin, ether, wintergreen, or camphorated oil helps to make the removal of plaster less of an ordeal.

Diagnosis.—Many of these cases are often associated with a chipping of the tip of the internal or external malleolus, and are then known as *sprain-fractures*. This type of case requires longer immobilization, as it is unsafe to permit actual use under three or four weeks.

Fig. 62.—Applying the non-slip bandage. Free end being overlapped.

Fig. 63.—Applying the non-slip bandage. Free end used as a tie to last turn of the roller.

Caution is needed in excluding a *fracture* of either malleolus without displacement; this is especially necessary where the violence has been great or where the symptoms are in excess of an apparent sprain. In cases of doubt a radiograph should be obtained; if this is impossible, it is wiser to regard and treat the case as one of fracture until the contrary is proved. Localized or "point" tenderness is very suggestive of fracture, for the tenderness of a sprain is usually quite generalized.

Knee Sprain

This usually is manifested as a synovitis.

Causes.—Ordinarily it is due to a wrench or twist of the joint in an effort to prevent a fall; or from the latter, so that the leg is more or less

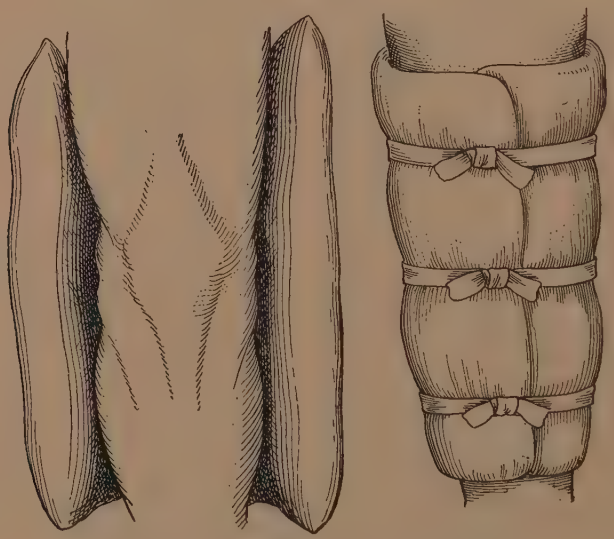


Fig. 64.—Pillow splint for knee-joint injuries.

twisted under the body. The external portion of the joint is more often affected than the other parts, and frequently there is coincident spraining of a portion of the capsular ligaments. It is practically impossible to diagnose sprain of the lateral ligaments of the joint, although rupture of these often occurs with dislocation. A synovitis is a usual accompaniment and ordinarily is the predominant feature.

Treatment.—If seen *early* the limb should be maintained in a perfectly straight position by a padded posterior splint reaching half-way up the thigh and down the calf respectively. Over this are placed plentiful compresses of ice-water or lead-and-opium lotion, a tight bandage encircling splint and compresses. The limb is then elevated

on a pillow placed lengthwise, so that the heel projects beyond its edge, the upper end of the pillow passing well above the hollow of the knee; in minor grades a pillow splint used as in Fig. 64 will answer. An ice-bag strapped over the splinted joint is often equally efficient. After twenty-four hours swelling and pain may subside enough to permit of additional constriction of the joint in an effort to restrain effusion. As soon as the acute symptoms subside (generally within a few days) the limb should be shaved for a foot either side of the joint and an interlacing of 1-inch wide "Z. O." adhesive plaster applied. The first strap begins about 6 inches *below* the joint, on the *outer* side of the calf, and is carried over the front of the joint just below the tubercle of tibia and attached to the *inner posterior* margin of the thigh, about 6 inches *above* the joint. The second strap begins on the *inner* side of the calf, about an inch internal to the beginning of the first strap, then across the front of the joint to the *outer* part of the thigh, about an inch away from the end of the initial strap. The third strap overlaps the first by half its width; the fourth strap over-

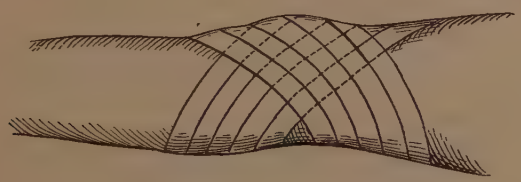


Fig. 65.—Adhesive strapping of knee.

laps the second to a similar extent, and additional straps are then criss-crossed until the whole joint is firmly encased. Caution must be observed in leaving a sufficient gutter on the posterior of the joint for circulation (Fig. 65). Over all an encircling snug bandage is applied and the limb kept elevated. An ice-bag can be used if desired. Any abrasion or wound is suitably protected by a few thicknesses of sterile gauze after iodin has been freely used.

This dressing can be retightened when necessary by additional broader straps, or wholly reapplied after it has become loose. Massage will be advantageous if employed early, and in most cases it can be borne after a few days. When pain on moderate passive motion ceases, it is safe to allow restricted active use with the joint suitably protected by adhesive strapping. Later a linen-meshed bandage, elastic, or leather knee-cap can be used, and this should be worn until pain on usage subsides. Swelling and occasional twinges of discomfort may persist several weeks, notably in those whose occupation requires per-

sistent bending of the parts. Athletes often need some such form of support for long periods to prevent recurrence, especially in such sports as jumping, hurdling, football, baseball, and running. A swollen, relaxed, somewhat tender knee is so commonly found in athletes, especially football players, as to be known as the "football knee."

In *recurrent* or *old cases* it is sometimes wisest to completely immobilize the joint in a light circular or anterior and posterior molded plaster-of-Paris splint. This should extend well beyond the margins of the joint, and if made removable, massage and vibration can be given as desired. This splint can be worn as long as tenderness on pressure exists, and then adhesive plaster or some form of knee-cap may be substituted. Ichthyol or iodin ointment applied on compresses is useful to remove remnants of pain or swelling. Likewise, baking of the joint and alternate douching with hot and cold water are helpful.

Diagnosis.—*Bursitis* is generally so well localized as not to be confusing, at least after a few days. *Slipping cartilage* usually occurs under lesser grades of violence, and "the locking of the joint" in a flexed position is quite characteristic. Later, localized swelling and tenderness corresponding to the site of the cartilage clears away doubt as to the actual condition, and often the displaced cartilage itself can be felt.

Gonorrheal and *rheumatic synovitis* are always to be thought of and even regarded as probabilities if the symptoms are disproportionate to the violence inflicted.

Tubercular, *syphilitic*, and *neuropathic* knees generally give associated symptoms of value, especially in old and recurrent cases.

Fracture can generally be readily ruled out, although some cases associated with massive synovitis may simulate fractured patella for a time. Likewise the symptoms may occasionally suggest a fracture of a condyle of the femur, or of the upper end of the tibia or fibula, but a careful examination will early disprove any suspicions of this sort.

Wrist Sprain

Causes.—Usually due to a fall on the outstretched palm or a twist of the hand with the parts above the joint more or less fixed. The external and anterior portions of the joint are most commonly involved.

Treatment.—If seen early, the adhesive strapping method is the one of choice. Strips of 1-inch "Z. O." adhesive are passed criss-cross over the posterior and lateral margins of the shaved joint in such a manner as to completely encircle it except for a small trough to allow

for circulation (Fig. 66). The hand should be slightly inclined toward the side of the affected ligament during the application of the adhesive. A snug gauze bandage and a sling complete the dressing. An ice-bag can be worn if desired. As soon as the pain and swelling subside to a degree (generally on the third or fourth day), light massage can be given through the adhesive, and the latter is removed in a week unless it becomes loose before then. Some passive motion is then permissible. Another similar adhesive strapping is now applied, and the patient is instructed to daily move and massage the joint. At the end of two or three weeks active motion is permitted, the joint meanwhile being protected by a cuff of 2-inch adhesive, or a leather wristlet, until pain on motion subsides. In cases seen late, especially those giving a history of recurrent sprain, or in rheumatics, children, the aged, or the nervous, the foregoing *active* form of treatment may not prove as satisfactory. In such cases a light encircling plaster-of-Paris or starch

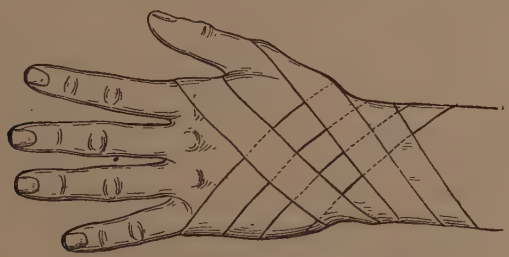


Fig. 66.—Adhesive strapping of wrist.

splint may be used after the local signs have receded under the use of an ice-bag, cold compresses (water, alcohol, or lead and opium). Such a splint should not reach beyond the finger webs, and must not be worn longer than ten days or a fortnight, otherwise adhesion may cause a troublesome stiffness more difficult to relieve than the initial injury. On removal of the chosen form of immobilizing dressing, massage with hot olive or camphorated oil should be given for ten to thirty minutes, and then the original splint reapplied, now so split that it encircles only one-half the joint. This is removed daily for massage and passive motion, and at the end of the week is discarded for a wristlet of leather or adhesive, active use from then on being encouraged up to the hurting point.

Diagnosis.—*Fracture* of the lower end of the radius or ulna, with little or no displacement, often gives similar signs in the first few days. Differentiation can generally be made early by ascertaining the presence or absence of (1) localized tenderness; (2) false motion; (3)

change in the level of the styloids; (4) alteration in the transverse wrinkles on the front of the wrist; (5) localized ecchymosis. Scaphoid fracture is distinguished by noting the absence of fulness and hard bulging of the "snuff box" region at the outer side of the joint. If doubt still exists, a radiogram may be needed.

Sprain-fracture is more difficult to differentiate than the foregoing; however, the treatment outlined for ordinary sprain will generally suffice for this injury, and in some cases only an *x*-ray examination can be decisive.

Sprain of the Back

This usually occurs in the middorsal or dorsolumbar region, although it occasionally occurs in the cervical section.

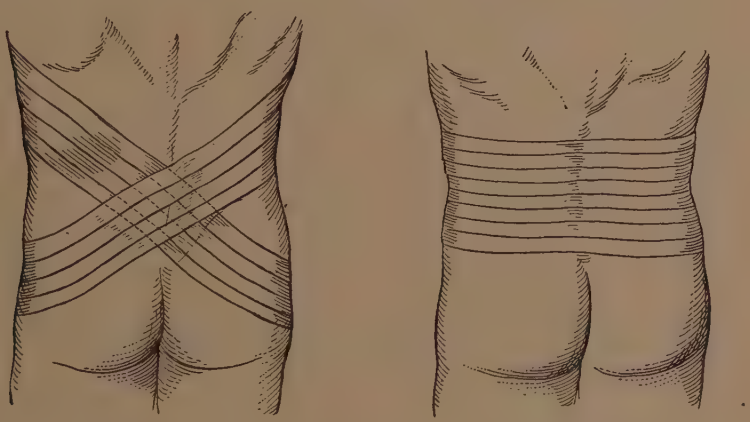
Causes.—A wrench of the spine from a sudden twist or bend is generally the cause; most of the cases follow the so-called "jack-knife" posture, in which the shoulders are sharply bent forward while the rest of the frame remains more or less rigid. Many of these cases follow stooping forward motions that are quickly followed by efforts at regaining the upright position with some weight in the hands or arms. I have seen several induced in this manner in parents who have bent sharply forward to the crib or floor to lift a child and then, while regaining the balance, a lateral twist occurs. Workmen with crowbars or other levers frequently sustain the same sort of sprain.

Treatment.—Strapping well above and below the involved part with criss-crossed 2-inch wide adhesive plaster is *the* method of choice. The adhesive lacing should extend well beyond each axillary level margin to be most effective, the spine being bent backward during the application (Fig. 67). Patients should be encouraged to walk as soon as the adhesive is applied, and the straps need not be removed short of two weeks unless they become loose or cause irritation meanwhile. During the time they are in place massage is very effective, and so is "ironing the back" with a heated flat-iron while the patient is prone. On removal of the strapping brisk massage and some increasing passive motion can be employed. Vibration and electricity and the actual cautery are adjuvants in the later or rebellious stages. Many of these cases apparently derive some comfort and support by later wearing a leather, flannel, or fabric encircling binder. In the rheumatic, suitable diet and a course of salicylates are of aid.

The so-called *traumatic lumbago* is a typical form of back-sprain in which induced rigidity of the back by adhesive strapping is very effective. Severe cases of this and allied forms may sometimes derive greater

comfort by the use of a light plaster-of-Paris or starch cast or other form of spinal jacket.

Diagnosis.—*Pain in the back* can arise from such a variety of causes that its persistence should call for an investigation as to the probable coexistence of former abdominal visceral prolapse, such as a movable kidney, enteroptosis, or pelvic displacement. Even such an apparently remote cause as flat-feet should not escape notice, nor should spinal deformity be forgotten. Many of these patients may be wholly unaware of these added factors and be honestly mistaken in ascribing their symptoms to an acute sprain, when, in reality, their suffering is of gradual onset and dependent upon structural or pathologic factors apparently remote or anatomically distant. Manifestly a patient with



a *b*

Fig. 67.—Adhesive strapping for a sprained back: *a*, Criss-cross strapping; *b*, transverse overlapped strapping.

an ordinary sprain will not respond to treatment directed alone to the sore spot if the fault lies in a part or viscus reflexly the source of irritation; hence these cases of "lame back" are often an expression of a distant source of trouble. It is not to be forgotten that "pain in the back" is likewise a frequent accompaniment of the hysteroneurasthenic group of symptoms, of neuritis, and of actual spinal cord lesions. For these reasons **prolonged pain** following the accused injury should put us on guard as to the possibility of other and more potent causative factors. Many of these patients on inquiry will give a history of occasional attacks of a similar sort which they interpreted as rheumatism, undue exertion, posture, or a variety of causes, which, in reality, sprang from a developing distant source.

If passive movement painlessly enables the back to be straightened, then the spinal ligaments are undamaged; if, however, more pain is caused on bending than straightening the back, then the trouble is probably related to the spinal ligaments (Gould).

Rheumatism is also an element that frequently calls for differentiation, and persons of the "uric acid diathesis" will sometimes not respond to local treatment alone and need the additional benefit of diet and antirheumatic medication.

Intercostal neuralgia and *neuritis* will ordinarily result in little confusion from a differential standpoint.

Sacro-iliac Sprains

Because this joint is normally well protected and enjoys very little motion it is very rarely injured except by severe falls with the thigh in abduction, or by unusual crushing or wrenching forms of violence in which other injuries also occur.

Symptoms.—These relate to localized pain on motion or pressure, accentuated by walking, rising, or sitting, and these are often coupled with backache or weakness. Abducting the thigh and pressing the wings of the ilium together induce localized pain over the joint.

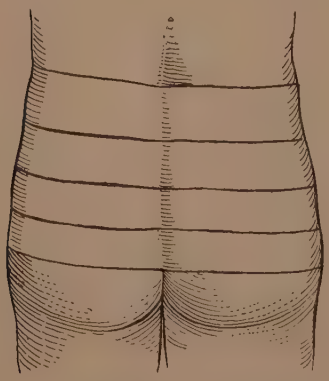


Fig. 68.—Adhesive strapping of sacro-iliac region.

Chronic sprain in this joint is the commoner manifestation, and is oftenest seen in women whose pelves are strained by pregnancy, and in those who have a relaxed musculature or a tendency toward visceral prolapse. Curvature of the spine or shortening of the lower extremities may impose pressure enough to cause symptoms of chronic sprain.

Treatment.—In the *acute* variety the parts are to be given rest by encasing them in straps of adhesive or plaster of Paris, passing completely around the pelvis (Fig. 68). After such a dressing has been worn a fortnight, a corset of leather or elastic can be substituted, and gradually dispensed with.

In *chronic* cases the true source must be ascertained, and if relaxation is alone at fault, some form of molded leather or metal corset will be effective in the vast majority of cases.

Injury of Tendons

WOUNDS, TEARS, RUPTURES

Tendons may be lacerated or actually severed, as by knife, axe, glass or saw cuts, or they may be subcutaneously ruptured by sudden twists or by severe joint injury ordinarily associated with fracture or dislocation.

Symptoms.—In those cases associated with *open wounds*, the signs will be obviously those of any laceration plus the visible or demonstrable severance of the tendon and the accompanying loss of function. In the larger joints (like the knee and ankle) the signs are apparent, but about the smaller joints (like the wrist and ankle) prolonged search is often necessary to determine the full extent of the tear or the tendon involved. This is especially so if much time has elapsed or if infection has ensued, so rapid is the tendency for the torn ends to retract. Without a dissecting incision it is often quite impossible to determine what degree of laceration actually exists.

In cases of *subcutaneous* (*closed wound*) tendon injury the difficulty is less in large joints where damaged function and increased range of motion render diagnosis fairly easy in the earlier stages before effusion or inflammation occurs; but in smaller joints, or where numerous tendons are grouped, the signs are confusing enough to make diagnosis only tentative in the absence of inspection through an operative incision.

In general, the symptoms common to all are: (1) Signs of sprain, synovitis, or both; (2) abnormal motility; (3) localized pain or tenderness; (4) ecchymosis, frequently quite late and diffuse.

Treatment.—The object is to (1) coapt; (2) immobilize; (3) restore function.

In severance of isolated or large tendons, posture or manipulation will sometimes coapt the torn parts, and adhesive plaster or starch or plaster-of-Paris splints will afford the needed immobilization during the process of uniting. Depending on their site, size, and function, tendons will knit in from ten days to four weeks. The *primary treatment* may well follow that given for the *active method* outlined for sprains, this to be followed (when swelling and reaction lessen) by a snug starch or plaster-of-Paris bandage. The first dressing should not remain longer than a week; if the swelling permits, it need not be used more than a few days. The starch or plaster dressing can be slit down the middle after the first week and then removed for massage, and later for passive motion. When pain on gentle manipu-

lation is at a minimum, active motion can begin gradually, and then the splint gives place to adhesive straps or bandages. Massage and use will ordinarily overcome joint or muscle stiffness and restore tone to weakened parts. In that class of cases where retraction is too great to be overcome by manipulation or posture, then the treatment must be operative and of the type mentioned below.

Open Rupture of Tendons.—Where a wound in the skin is present and the severence of the tendon is obvious, treatment is by suture. If the original wound is sufficient to expose the tendon it is quite likely that little or no retraction has occurred; generally the original

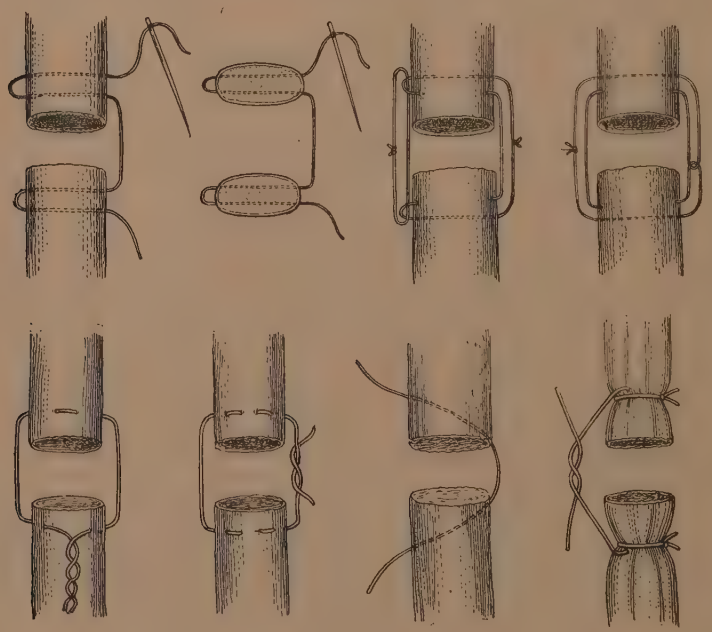


Fig. 69.—Tendoplasty methods.

wound requires enlarging, and this must be adequate enough to permit identification and coaptation. Assuming that the tendon is *unretracted*, then it can be joined by chromic catgut, kangaroo tendon, fine silk, or linen sutures meshed in the tendon ends after the manner shown in Figs. 69, 70. Plain catgut will not hold long enough and, therefore, should not be used. If *retracted*, then much search may be necessary to find either the proximal or distal end, especially about the wrist, where an interval of several inches is not uncommon.

In the search (1) follow up the sheath with narrow forceps and try to pull an end into view; (2) massage the muscles toward the wound

in an attempt to "milk" the tendon into the field; tight bandaging from above down may aid in this; (3) probe the sheath as far as the opening in it appears to extend, and then cut down upon the point of the probe by a fresh incision, or prolong the original incision along the probe.

If the gap is too great to be bridged over when traction is made, then length can be gained by any of the schemes indicated by the illustrations (Figs. 69, 70). If the tendon is too small to allow these methods, then a trellis of twisted silk or catgut can be interposed as shown in Fig. 70, *c*, or a strand of fascia or periosteum can

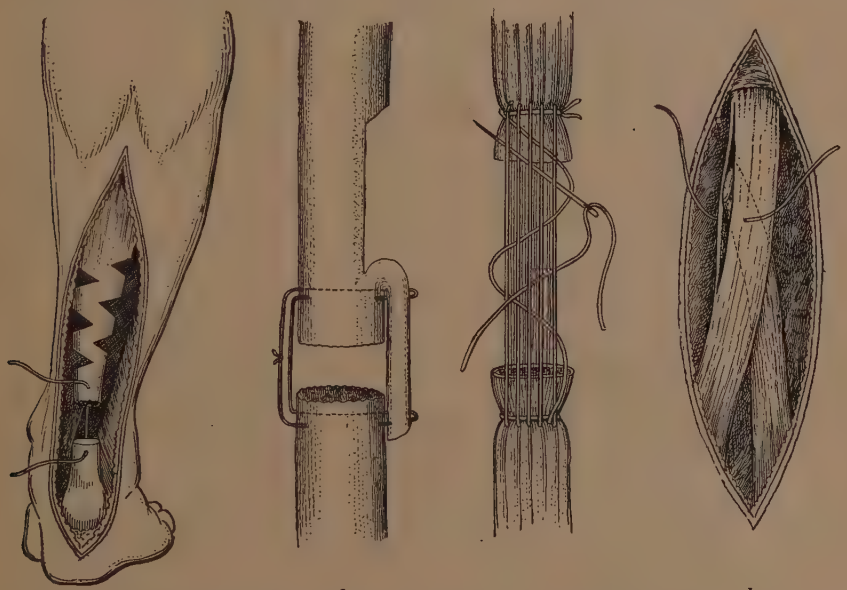


Fig. 70.—Tendon lengthening: *a*, Tendo Achilles; *b*, tendon bridging; *c*, interposition of thread trellis; *d*, tendon splitting and transfer.

be substituted. Failing still to unite the torn tendon, it can be attached to (1) an adjacent tendon; (2) stitched to the periosteum; (3) buried subperiostocally. Whatever the method, strict asepsis must be practised and every attention given to providing proper drainage and relief from tension where needed. Even in the presence of a wound requiring daily dressings, provision can be made to splint the part in an overcorrected position so that union may occur. Small tendons unite in two weeks sufficiently to discard the splint or retentive apparatus; large tendons need support a month or six weeks. Massage and passive motion will test the union and determine when active use may begin.

SUBCUTANEOUS INJURY OF SPECIAL TENDONS

The **Achilles tendon** may rarely be ruptured by a forcible fall on the heel or wrench of the foot.

Symptoms.—Immediate pain and disability ensues, with swelling and ecchymosis soon thereafter, together with loss of plantar flexion.

The **plantaris tendon** of the calf of the leg is frequently torn by a sudden twist of the leg, as in stepping on an uneven surface or from one level to another, or by more active use of the part, as in running, jumping, or hurdling.

Symptoms.—Immediate sharp pain at the inner side of calf appears, often accompanied by faintness and actual falling. There is difficulty

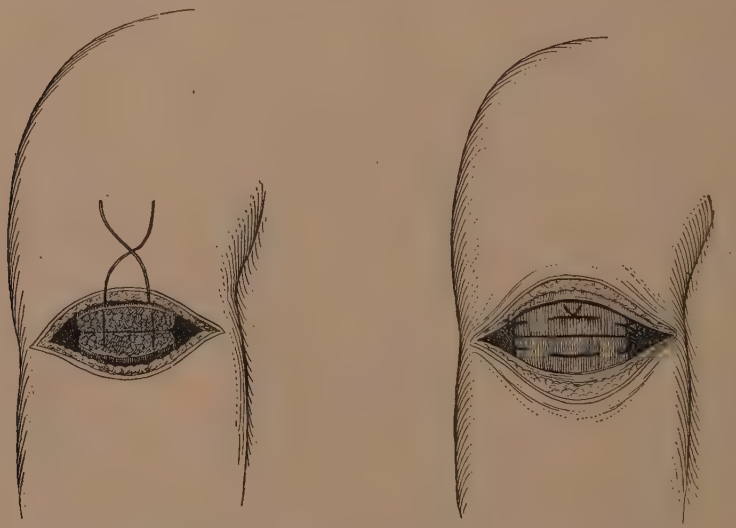


Fig. 71.—Ruptured biceps muscle and method of catgut suture.

in walking, and on examination the calf will be swollen and present localized tenderness on pressure and pain on motion. Later, varying from one to thirty-six hours, there will be diffuse ecchymosis that may affect the whole of the posterolateral margins of the limb and a hematoma may form at the site of rupture.

The **soleus group** of the calf of the leg may be ruptured by violence similar to that of the foregoing, but greater in degree.

Symptoms are those of plantaris injury, but more marked, and generally there will be a visible or palpable sulcus at the place of disruption, generally at the middle of the limb.

The **patellar tendon** is not infrequently ruptured by a sudden contraction of the knee while walking, tripping, running, or stepping from

one level to another; occasionally it is torn by direct violence in a fall or blow on the knee, but then it is ordinarily associated with a fracture of a small portion of the lower edge of the patella, this then being an example of so-called "sprain-fracture."

Symptoms are those of tendon rupture elsewhere, plus bursitis or synovitis, and elevation or excessive vertical mobility of the patella.

The **quadriceps tendon** occasionally is ruptured at its lower third or just where it joins the patella by some form of direct violence, such as a blow or a fall astride an object, or by indirect violence, as from a sudden powerful twist or wrench.

The *symptoms* are similar to those given for the foregoing.

The **adductors of the thigh** are occasionally torn at their extremities or centers by indirect violence, such as forced abduction postures due to falls or other maneuvers simulating "doing the split." The *symptoms* are as narrated above.

The **biceps** and **triceps** are occasionally torn at their origins, insertions, or intervening parts by sudden jerks or twists of the shoulders, arm, or elbow; rarely are they involved by direct violence.

The *symptoms* resemble those named for involvement of the calf and thigh tendons (Fig. 71).

INFLAMMATION OF TENDONS

This occurs in the form of tenosynovitis (thecitis) due to primary injury of the tendon, but ordinarily it is a secondary manifestation following infection or prolonged immobilization, as in fractures or dis-

Fig. 72.—Ganglion of wrist.

locations. It may be also due to rheumatism, gout, gonorrhea, syphilis, and tuberculosis.

In a localized form, over an isolated area of a tendon, a circumscribed cystic swelling may occur, known as "ganglion" or "weeping sinew." This may rarely follow a single blow upon or a twist or wrench of the part, but generally it is a slowly developing swelling of unknown origin that may be ascribed to constant use of the affected tendon.

The back of the wrist and palm are the favorite locations, and less often the flexor surfaces of the wrist are affected; they seem to be commoner in relatively idle young women than in working-men (Fig. 72). Certainly they are rarely seen as acute sequels of localized trauma. Sometimes they are multiple, and are then called "compound ganglion," and such swellings on pressure can be made to pass from one level of the joint to another; these, however, are more likely to be tubercular in origin.

Treatment.—Occasionally (1) *pressure* maintained by adhesive or other strapping (aided by a gauze pad, coin, or cork) is effective. They can be (2) ruptured by a sharp blow struck while they are tense; the edge of a book is usually chosen for this purpose. Oftentimes this treatment acts well in recent cases. (3) Injection of iodin occasionally answers. Removal by (4) incision and complete dissection of the sac under local anesthesia is the only radical method of cure. To accomplish this a semilunar incision will give better access than a straight incision. Rarely can the cyst be excised intact, but in any event the operation to be effective must remove all or most of the cyst wall. Recurrence is not infrequent even under radical procedures.

Tenosynovitis

This may manifest itself as a simple irritative lesion or as the sequence of some infection. The wrist and the ankle are most commonly affected in the simple form, and a sprain, fracture, or dislocation is the usual source. Certain occupations may induce the condition by continued pressure.

Symptoms.—Following irritation of the tendon sheath its lining becomes roughened and later an effusion forms, this being the same process that occurs in any other serous membrane. The early signs are pain and stiffness on motion, followed by grating or creaking; later, the swelling and fluctuation denote effusion.

Treatment.—On removal of the source of irritation, *rest* is provided; if necessary, adhesive strapping or bandaging will best accomplish this. If effusion is present, care must be taken not to permit adhesions to form on subsidence of the fluid. Early massage and use prevent as well as cure cases of this sort and make chronic manifestations unlikely. In old cases, with fixation more or less complete, forced massage and calisthenics will accomplish much if the patient is willing each day to stretch the parts a little more than the day before. Baking and alternate douching with hot and cold water are also serviceable. In

very resistant cases anesthesia may be needed to forcibly overcome contractures. In such an event massage and passive motion must begin very promptly, otherwise the condition will become reëstablished. The *infective* form is a sequence of wounds, and has been mentioned in connection with Infected Wounds, notably under the heading Infections of the Hands.

Tubercular and *syphilitic* forms may also occur and give symptoms typical of these respective processes in other parts of the body.

BURSITIS

An inflammation of the bursa may occur acutely as the result of a single direct injury, but generally it is the outcome of persistent or repeated trauma, or a result of irritation from pressure or overuse.

Symptoms.—Common to all acute forms are (1) swelling, usually localized and often associated with contusion evidences like redness or ecchymosis; (2) pain on pressure or use; (3) fluctuation without attachment to overlying or deeper parts; (4) interference with function.

In the chronic forms, globular swelling and more or less fluctuation, pain, and impaired function are the ordinary manifestations.

Treatment.—In the *acute* form, rest and cold wet dressings followed by pressure of adhesive straps or bandaging usually suffices, the pressure to be repeated until the effusion is squeezed out. In the *chronic* form (1) *aspiration* of the fluid via hypodermic needle or trocar; (2) aspiration, and injection of 2 per cent. formalin in glycerin, iodin ($3\frac{1}{2}$ per cent.), or iodoform and glycerin; (3) exsection of the sac.

Many of these ancient cases are bothersome and annoying rather than painful or serious, and cosmetic rather than surgical necessities bring them to the attention of the surgeon. Merely from an esthetic standpoint, they are often better left alone.

Special Forms of Bursitis

Prepatellar bursitis (housemaid's knee) sometimes occurs acutely from violence producing a sprain of the knee, such as a wrench, fall, or blow (Fig. 73). Commonly it is due to pressure in kneeling, but nowadays it is rare since the advent of mops, vacuum cleaners, and other household labor-saving devices. The other bursæ about the knee are less rarely affected (Fig. 74).

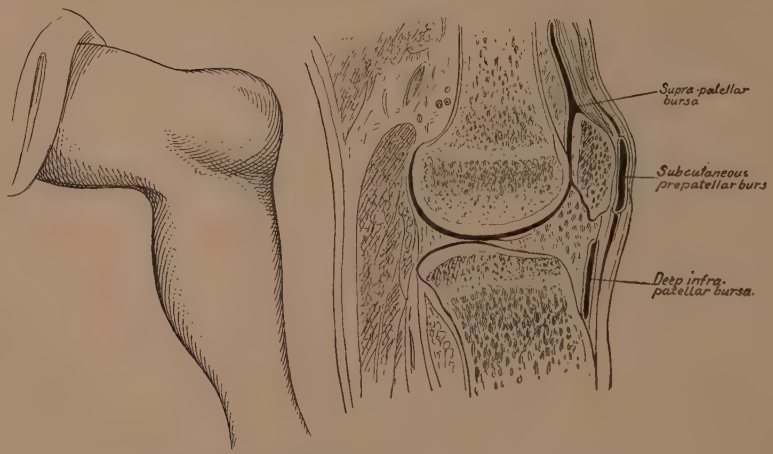


Fig. 73.—Prepatellar bursitis (housemaid's knee).

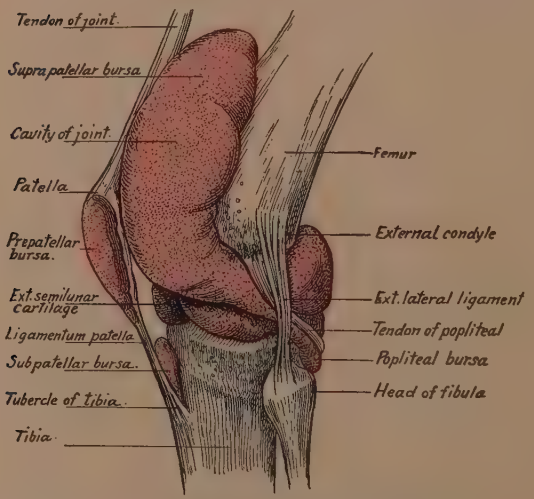
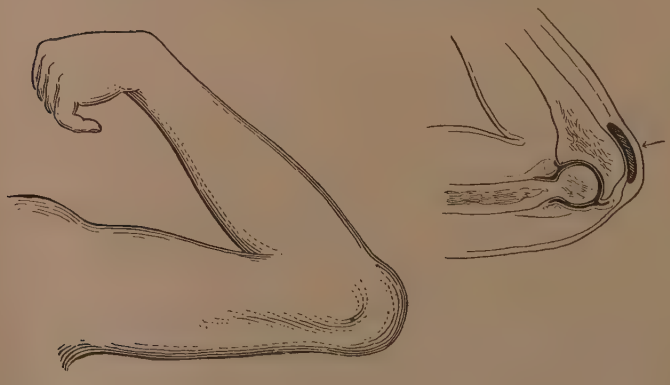


Fig. 74.—Structures about knee showing bursæ.



a *b*

Fig. 75.—Olecranon bursitis: *a*, External location; *b*, internal location.

Fig. 76.—Plaster spica and retention of abduction by posture without splints. (These and the following drawings are from the articles of W. M. Brickner who has made an intensive study of this lesion.)

Fig. 77.—Plaster spica and retention of abduction by posture without splints.

Olecranon bursitis occasionally occurs from elbow sprains or blows on the summit of this joint (Fig. 75). Ordinarily it occurs in occupations requiring pressure over this area, as in miners; hence the name "miner's elbow."

Subacromial bursitis occurs usually from twists or forcible abduction motions of the upper arm, but occasionally also from direct forms

Fig. 78.—Subacromial bursitis (radiographic appearance).

of violence. Codman, Brickner, and others regard it as a fruitful source of shoulder disability. The visible evidences of the condition are usually indefinite, although slight swelling may occasionally exist below and in front of the acromion. The best single evidence of the lesion is

Fig. 79.—Subacromial bursitis (radiographic appearance).

Fig. 80.—Subacromial bursitis (radiographic appearance).

localized pressure pain over the bursa, and this is increased by efforts to abduct or rotate the arm. Calcareous deposits may occur, and these often show quite plainly in radiograms.

Treatment is by external cold applications, the arm being held in forcible abduction (as in Figs. 76, 77). If, after a reasonable trial,

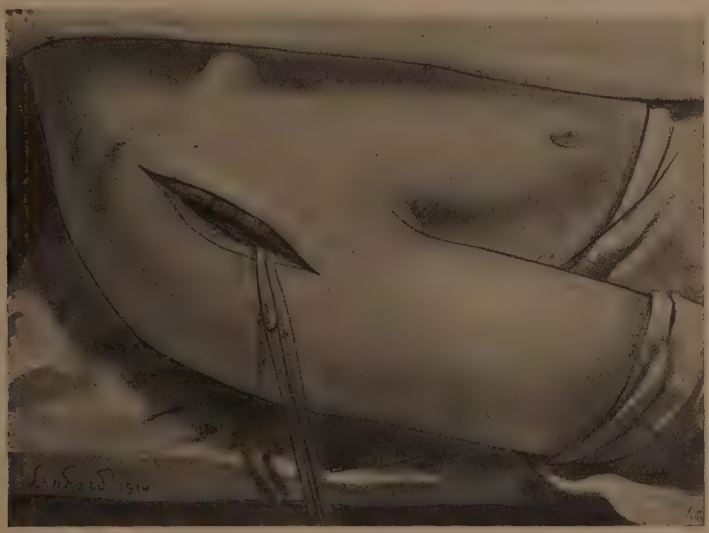


Fig. 81.—Operative steps in removal of the contents of the bursa.

this proves ineffective, operation may be resorted to after the plan shown herewith from Brickner's writings.

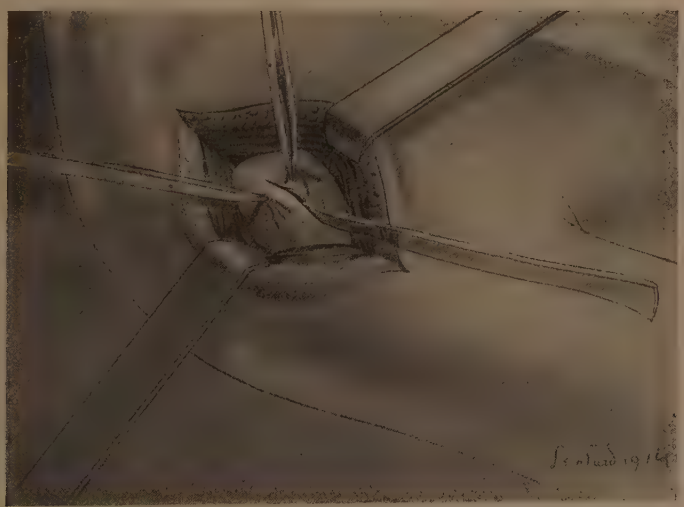


Fig. 82.—Operative steps in removal of the contents of the bursa.

Personally, I regard this form of bursitis as rather rare and would not resort to operation in the absence of very convincing radiographic evidences that fully fitted the clinical signs (Figs. 78–86).

Heel bursitis, at the insertion of the tendo Achillis, may rarely follow a sprain or a blow; but generally it is sequential to ill-fitting boots, high-heeled slippers, or "ties" (Fig. 87).

Fig. 83.—Operative steps in removal of the contents of the bursa.

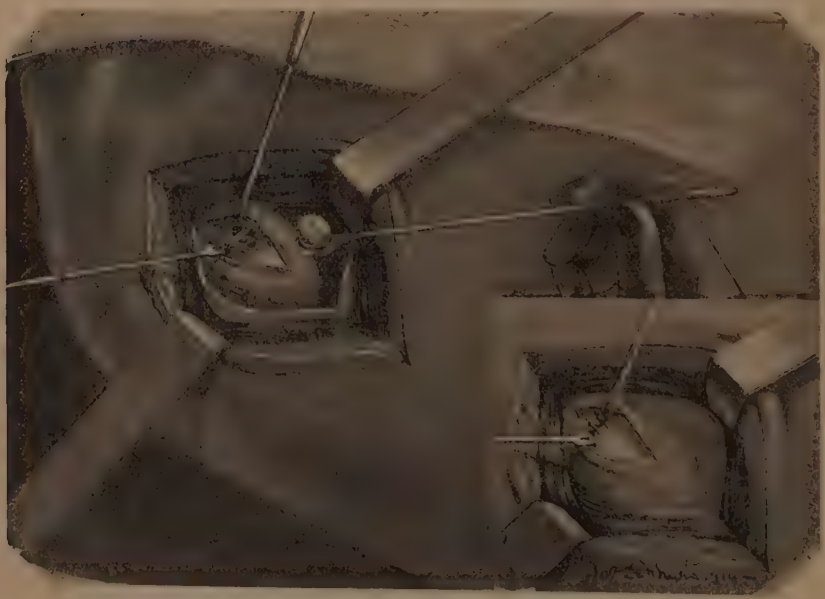


Fig. 84.—Operative steps in removal of the contents of the bursa.

Ankle bursitis may infrequently follow a sprain or a blow; usually posture is the real factor, as in tailors, hence the term "tailor's ankle."

Big toe bursitis is practically always due to pressure from tight shoes, resulting in the common "bunion," with or without the accom-

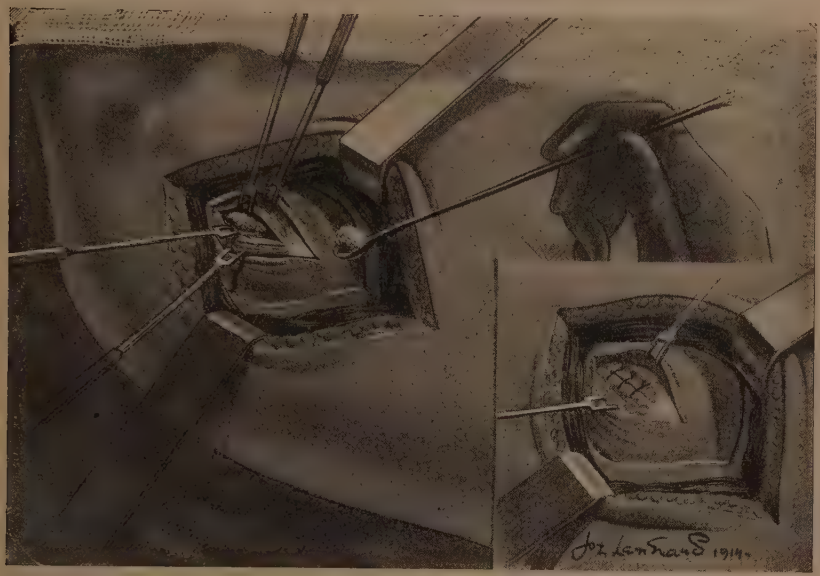


Fig. 85.—Operative steps in removal of the contents of the bursa.

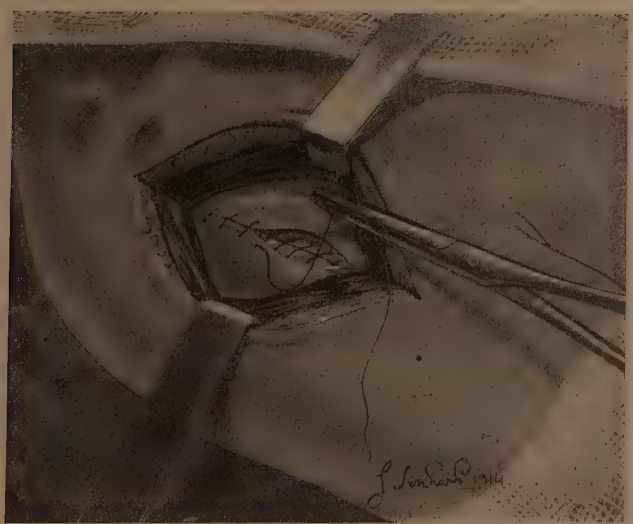


Fig. 86.—Operative steps in removal of the contents of the bursa.

panying change in the bones at the metacarpophalangeal joint (Fig. 88). There seems to be a marked congenital and family predisposition to this type of swelling.

Hip bursitis, over the tuberosity of the ischium, is generally a pressure occupational irritation, and boatmen occasionally develop it.

Infected Bursæ.—These occur in connection with wounds or as metastases, and in effect are abscesses and are treated by puncture or

Fig. 87.—Tendo Achillis or calcaneal bursitis.

Fig. 88.—Hallux valgus or bunion.

incision and drainage. Rheumatism, gonorrhea, and tuberculosis are often causative factors.

SYNOVITIS

Every joint is lined by a smooth two-layered serous membrane secreting enough viscid synovial fluid to properly lubricate the joint. When this membrane becomes irritated there is an increase of fluid, and synovitis is produced; in common parlance, there is "water on the joint." If blood is also present we speak of *hemorrhagic synovitis*. If infection occurs, *purulent synovitis* is the term employed.

Causes.—It may result from indirect violence, as in sprains, ruptured ligaments, slipping cartilages, dislocations, or fractures; or from direct violence, as by a blow or fall upon a joint. The joints most commonly involved are the knee, shoulder, and elbow. Aside from injury there are many other producing factors, notably rheumatism, gout, gonorrhea, syphilis, tuberculosis, and certain diseases of the central nervous system like tabes and syringomyelia.

Acute and *chronic* forms are recognized.

Symptoms.—These can be conveniently divided into periods or stages, called (1) ascent, (2) stationary, (3) subsidence. Common to all *acute* forms are:

(1) *Swelling* limited to the extent of the synovial pouch.

(2) *Redness*, occasionally present, and it may be associated with ecchymosis when arising from either direct or indirect violence.

(3) *Fluctuation* or *bogginess.*

(4) *Pressure tenderness* or *pain.*

(5) *Increase of joint motion.*

(6) *Diminished active* and *passive function.*

(7) *Atrophy* of adjacent muscles is generally a later manifestation, but is generally present within a week, to some extent at least.

In the *chronic* form the main signs are:

(1) *Swelling*, less globular or marked than at first.

(2) *Muscular atrophy.*

(3) *Fluctuating* to some degree, or it may be replaced by *crepitation* due to the presence of joint bodies of small size; or there may be a palpable foreign body from absorbed effusion.

(4) *Tenderness* or *pain* on manipulation and motion.

(5) *Diminished function.*

(6) *Audible grating* or *creaking* is not uncommon.

In extent, synovitis may be of three degrees:

First degree, where the joint outline is somewhat broadened.

Second degree, where the joint outline is greatly broadened.

Third degree, where the joint outline is obliterated and the joint structures are more or less separated.

Treatment.—This aim is to (1) reduce the effusion; (2) restore function; (3) prevent recurrence. These designs can be summed up by the terms (*a*) rest, (*b*) immobilization, (*c*) functionation. Inasmuch as the knee and shoulder are most commonly involved the treatment given them will be detailed later. Synovitis of the other joints can be treated after the manner indicated for sprains.

Course and Prognosis.—The average duration is from two to twelve weeks, depending upon the site and extent of the effusion, the patient's age, occupation, physical type and tendency toward other ailments, and upon the treatment. Certain cases treated too long or too short, or because of constitutional tendency, readily have recurrences and develop a more or less well-marked habitual swelling that ordinarily is more inconvenient than actually painful or disabling. This type is common in the athletic, the rheumatic, and the syphilitic.

Synovitis of the Knee

In addition to the usual and ordinary symptoms, this presents in typical cases the classical signs of "floating patella" and "clicking patella" (Fig. 89). These manifestations are brought out by crowding the upper and lower edges of the synovial sac toward each other by the examiner's hands, and while so doing a flick on the patella will

elicit the "click" or "tap" and at the same time demonstrate the floating (Fig. 90). In this region particularly a massive effusion disproportionate to the accused injury should put us on guard lest we overlook the true etiologic factor, such as rheumatism, gonorrhea, tubercu-

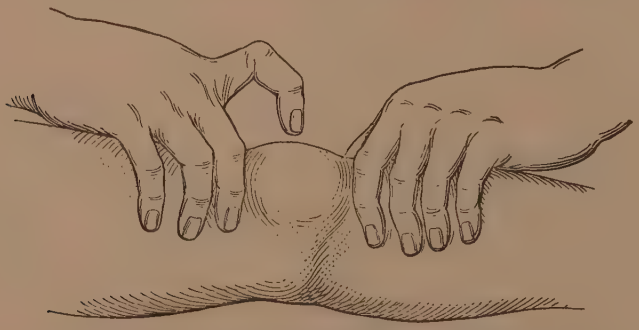


Fig. 89.—Eliciting the "tap" or "click" of the floating patella in synovitis of the knee. Note how the palms are used to gather the fluid under the floated patella so that the index-finger may percuss and elicit the "tap" or "click."

losis, or some disease of the central nervous system capable of causing a "Charcot joint" (Figs. 91–93).

Treatment.—For the first few hours it may be well to put the knee at rest merely by placing it in the hollow of a long pillow, an ice-

Fig. 90.—Synovitis of the right knee.

bag resting over the part, but being separated from the skin by a towel or layers of gauze. It takes from one to five days for the effusion to reach its maximum, but early pressure may prevent further exudation if the following form of "rail-fence" dressing (Fig. 94) is applied

at once. This is made by applying an encircling layer of absorbent cotton (or sheet-wadding or cotton-batting) about the joint at least

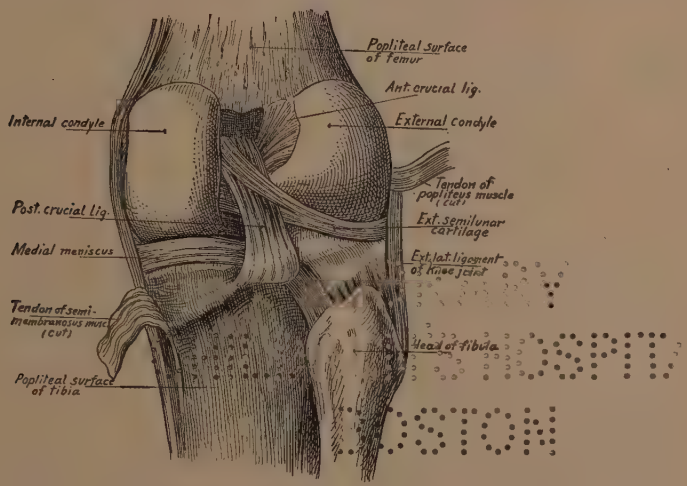


Fig. 91.—Structures of knee-joint, posterior view.

6 inches above and below the swelling. Several ordinary bass-wood splints meanwhile have been soaking in hot water to render them

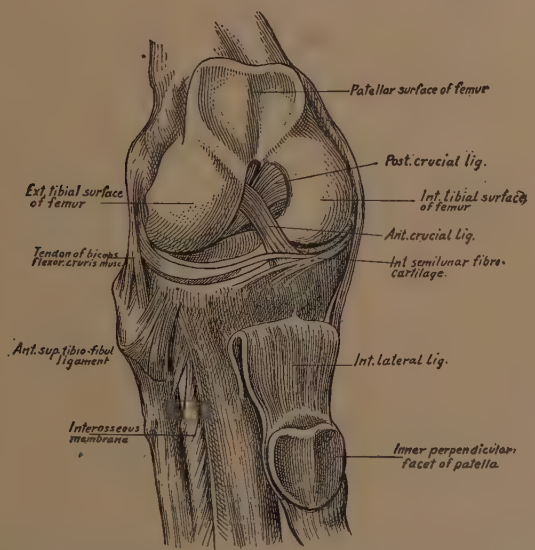


Fig. 92.—Structures of knee-joint exposed by cutting the quadriceps tendon.

pliable, and now a splint is split longitudinally in three or four pieces. These are laid vertically around the anterolateral margins of the joint,

about ½ inch apart, over the absorbent cotton, and then a tight muslin bandage secures them in place. An ice-bag surmounts the patella if any comfort is derived from it. The limb is then placed on a hollowed long pillow or rests on the bed between sand-bags, the foot being raised as much as the patient will permit. Such a dressing provides a surprising amount of equally distributed transverse and vertical pressure, and it is capable of easy regulation according to necessity. The outside bandage can be tightened daily if the absorption will permit. Occasionally I have placed these slats on adhesive before applying them, and in that fashion they are somewhat more easily handled, but then they must be applied dry, and for that reason do not mold quite so well.

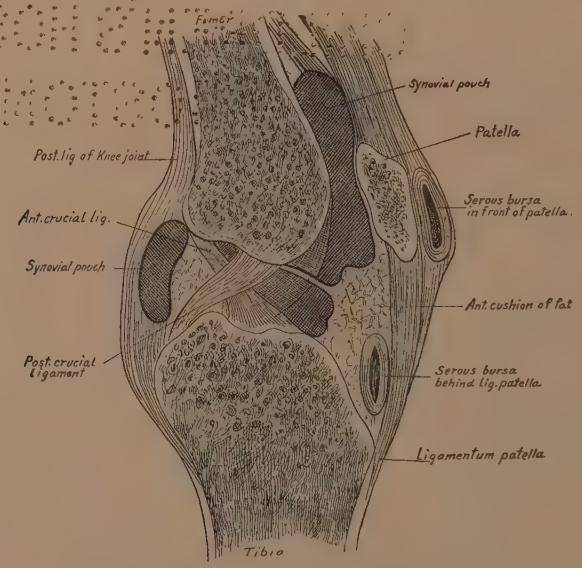


Fig. 93.—Structures of knee-joint, sagittal section.

When pain on pressure subsides (usually in two weeks or less) it is wise to give massage daily to still further promote absorption. A week later some passive motion can begin, and as soon as this is borne comfortably the patient can be allowed to bear weight and later walk, the joint being incased then in adhesive plaster or a linen-meshed or rubber bandage or fitted knee-cap. Some such support is usually desired and affords comfort and confidence during further convalescence. When the period of walking is reached, the patient can by self-massage increase the joint tone and restore muscle power; hot camphorated oil is good for this purpose. Allowing a forcible jet of hot and then cold water to spray on the knee is excellent; a piece of rubber-hose

attached to the faucet answers for this. If joint stiffness occurs despite these measures, the use of an ointment of ichthyol (10 to 25 per cent.) or iodin will be of value. Electricity and vibratory massage are quite valuable and baking is notably efficient. Persistent swelling and stiffness will be less likely if massage is begun as soon as pain on pressure and slight manipulation ceases. The average case responds well to the foregoing "active form" of treatment. However, in the young or the aged, or with some nervous types of individual, or where co-operation is not accorded for a variety of reasons, it may be neces-

Fig. 94.—The "rail-fence" dressing for synovitis of the knee. A layer of absorbent cotton encircles the joint and on this bass wood strips 1 inch wide (from a split wet splint) are laid and bandaged. As the swelling subsides, the bandage is retightened. Note the method of keeping the knee in extension, allowing free use of both hands.

sary to resort to a more "passive form" of management. In such a contingency the pillow and ice-bag can be used until the swelling reaches the maximum (generally by the end of the third day), then an encircling plaster-of-Paris splint is applied, reaching from the center of the thigh to the center of the leg, the joint being *well* padded. The foot is then elevated and the cast is worn until it loosens. Then (usually in two weeks) it is cut down the center and removed and a slit of a couple of inches is cut from it, and it is then tightly reapplied for a week longer. At this removal, massage certainly should begin, and repetition of it on alternate days will be grateful; the cast can be

worn in the interval if desired. From then on the treatment designs to "limber up" the joint and strengthen the weakened and atrophied muscles.

Strapping of adhesive plaster may prove of value after either the "rail-fence" or plaster splint.

It is rarely necessary to **aspirate** the fluid; in such an event the parts should be washed with alcohol, then dried with sterile material, and then coated with iodin. The place of puncture can be previously cocainized or frozen with ethyl chlorid; generally neither is needed. A mixture of equal parts of ice and salt laid on the joint provides an efficient improvised freezing method for this or any regional anesthesia. The aseptic aspirating needle is introduced at the inferior lateral margin and the fluid is encouraged to escape by downward pressure until no more exudes, or a suction needle is introduced. After all the fluid escapes, the injection of 1 to 3 drams of 2 per cent. formalin in glycerin (prepared twenty-four hours in advance) is recommended by some; likewise a similar amount of tincture of iodin. But this "injection method" is more properly applicable to the chronic forms. Whatever the treatment, the patient must be cautioned against undue use of the knee for a time and is advised to be properly and safely shod.

In the *chronic* and *recurrent* forms the outward manifestations are generally less marked, but often a huge swelling causes few subjective complaints. In this type the joint will permit very active and prompt pressure, and for that reason early use of the "rail-fence" splint can be advised. If despite firm pressure the effusion tends to persist, aspiration may be employed, *but every aseptic precaution* must surround its use, as the knee-joint is particularly susceptible to septic invasion. The needle or small trocar is introduced after the manner indicated above, and when the fluid is removed the formalin or iodin may be introduced. The puncture is then sealed by cotton and collodion, gauze or adhesive, and then the part is rubbed to bring the injected material into every portion of the synovial sac. It is thereby hoped that reaction will ensue, thus inducing an increased blood-supply and absorption. Reaction after this may manifest itself in the form of increased local effusion, and occasionally by systemic symptoms, with fever and malaise for a few days. In this interval the joint is at rest and covered with a moist cold saline dressing or an ice-bag. Thereafter massage and motion are to be instituted in the same way as indicated for the subsidence period in the acute forms.

Synovitis of Shoulder

This is often quite difficult to differentiate from contusion, sprain, arthritis, subdeltoid bursitis, and ruptured capsular ligaments; and, indeed, it may coexist with one of these. The ordinary *symptoms* of synovitis are present, but disturbance of function (elevation beyond a right angle notably), atrophy, and swelling, in the order named, are the main signs. As an entity it is comparatively rare.

Treatment.—Rest, with the arm at the side or the forearm in a sling or other support, with a cold wet dressing or ice-bag on the shoulder-cap, is needed until the period of ascent passes, and this usually requires from two to five days. During the stationary period light massage can be given if pain is not produced; otherwise the arm is kept at the side by a sling, and cold or hot fomentations (like lead-and-opium wash) can be used until massage is allowable. Passive motion gradually commences, rotation and abduction being first employed; circumduction and overhead extension will be the last to be regained. Active motion is advisable only within short range at first, and its progress can be gaged by having the patient stand at arms' length from the wall and each day place a mark thereon to denote how high the part is raised. Caution must be given to incline the body *toward* and not *from* the wall, for in the latter the whole shoulder-girdle will be moved and not the shoulder-joint alone.

Hemorrhagic Synovitis

This occurs rarely and is generally an associate of fracture or dislocation about the joint, as in a fractured patella or olecranon, or dislocation of the knee, shoulder, or elbow.

Symptoms are those of effusion, and the condition is differentiated with difficulty from ordinary synovitis in the absence of incision or aspiration.

Treatment.—This is the same as for other forms of synovial effusion in the absence of associated injury; in this latter event the management is that appropriate to the associated complication. Aspiration of the synovial sac is more likely to be needed in this form than in ordinary synovitis, and there is great likelihood that infection will supervene demanding incision. This form occurs also in certain anemias and in other constitutional ailments.

Purulent Synovitis

Generally this is secondary to simple or hemorrhagic synovitis, and most commonly follows the introduction of germs into the syno-

vial pouch by wounds or punctures. Occasionally a simple synovitis is made purulent by ill-designed attempts to aspirate an ordinary effusion. It may be an associate of an infected fracture or dislocation and sometimes is a metastatic manifestation, as in pyemia. The staphylococcus is the ordinary offender, and it may appear metastatically from a distant focus that may or may not be traumatic; for example, tonsillitis may be a source of origin. From constitutional sources it may arise from gonorrhea, tuberculosis, and other systemic diseases of non-traumatic origin.

Symptoms are similar to those in ordinary synovitis plus more local heat and redness. Usually there will be fever, chills, and signs of sepsis; some cases, however, may be practically afebrile.

Treatment.—This is by aspiration or incision and drainage; the first is preferable if the pus is not coagulated.

Chronic Synovitis

Generally this is sequential to an acute attack, but it may arise also from a variety of constitutional causes, notably rheumatism, gonorrhea, tuberculosis, syphilis, arthritis deformans, and certain forms of anemia and nervous diseases. A well-defined type occurs from relaxed joints or the muscles about same. Foreign bodies within the joint (slipping cartilage, joint fringes, and the like) also are causative. At puberty, menstruation, and menopause periods this form of joint effusion may also appear. Another form, often bilateral and periodic, occurs often enough to be given the special name of "intermittent hydrops."

Symptoms.—These resemble those of the acute form, except that the signs are less pronounced, but atrophy may be more marked. The things most complained of are weakness and pain on undue use or motion; while the part is relatively at rest there is comment as to the swelling alone, as a rule. The joints usually show more or less peri-articular thickening, and their motility is often impaired by some plastic or fibrous exudate occasionally causing an audible and palpable crepitus or creaking. Exacerbation is common and barometric changes are often complained of. Many of these cases show gait defects, and nearly all of them feel more comfortable after the joint has been "limbered up" by moderate use.

Treatment.—This depends largely on the duration and previous management, and a good deal on the age, occupation, and co-operation of the patient. An ordinary case that arises solely from injury will respond well to efforts designed to (1) remove the fluid; (2) restore

muscle tone; (3) support the joint and prevent recurrences. The *fluid can be removed* by any of the means suggested in the *acute* form until it is demonstrated that these *pressure* and *rest* objects are unattainable except by more drastic measures. Aspiration under perfect asepsis is then advised, with or without the injection of iodin or formalin-glycerin, as mentioned hitherto. To *restore muscle tone* and strengthen relaxed and shrunken soft parts we employ massage, vibration and electricity, and some motions that will not too severely tax the joint. Douching alternately with hot and cold water is excellent. To *support the joint* the wearing of a linen-meshed bandage or knee-cap is advisable, this to be removed on retiring. Caution is to be given about making sudden flexion movements or maneuvers that will tax the joint.

In cases arising from other sources the *treatment* must be aimed at the originating source, it being remembered that the tendency is often to accuse an injury when the actual cause may be some unknown or known constitutional difficulty. This is especially true in rheumatic, gonorrheal, syphilitic, or tabetic cases; either of these may be at the basis, and cure will be impossible until they are recognized and treated.

ARTHRITIS

This is an inflammation of the articular surface of a joint, often showing a tendency toward involvement of other adjacent joint structures.

Causes.—Primarily it may arise from injury by *direct violence*, as by a blow or fall directly on the joint; less often, *indirect violence* is at fault, as from a wrench or pull on the joint. Secondarily, it may occur from some inflammatory focus ordinarily adjacent, but occasionally at a distance; thus, it may accompany a synovitis or ostitis of the same joint, or be a metastatic process from a distant focus, as from oral or other sepsis. Aside from injury there are numerous other causes, notably rheumatism, gout, gonorrhea, tuberculosis, and syphilis. Typhoid, pneumonia, and influenza are also factors of origin.

Forms.—Acute, chronic, and purulent (septic) arthritis are recognized.

Symptoms.—In the *acute* variety there is the history of direct or indirect joint trauma, followed by swelling, redness, pain on pressure, heat, and diminished motion. The patient complains of initial pain that may have been exquisite enough to cause pallor, fainting, nausea, or vomiting, and which later decreased, but is aggravated by use of the part. Certain joints or portions thereof when injured seem to cause

more pain than others; this is notably true of the inner side of the knee. If the violence has been severe, disability may be complete and demand immediate aid. If the injury is general to all parts of the joint there will be added the signs of synovitis. The symptoms given may be present only over a portion of the joint, as, for example, on a lateral or superior margin; when generalized, an effusion into the synovial pouch usually coexists.

The *chronic* variety grows out of the acute form and presents similar signs, but to a lesser degree, notably as to freedom from local heat and extreme tenderness or pain; crepitus is generally elicited and it may be audible. The peri-articular soft parts are generally more rigid than normal and there is a general feeling of thickening; measurement may demonstrate an increase from ½ inch upward. Less enlargement than this minimum may be a normal variant due to age, physique, occupation, and the natural effect of usage, as between a right or left limb. If the enlargement is to be regarded as normal there is likely to be similar variation in the adjacent musculature. Many of these chronic cases, especially if recurrent, show marked limitation of motion due to adhesions in or about the joint; muscular or ligamentous contractions may coincidently or independently exist. Limitation of motion usually means atrophy of muscles even though the articular parts are enlarged. Knobbed irregularities about a joint indicate an ancient process as a rule. A chronic synovitis may coexist.

The *purulent* form (*septic arthritis*) may be a primary process following joint puncture (as by wound or bullet); generally it is a secondary manifestation of an adjacent or distant pus focus. The first evidence may be a chill followed by fever, and soon follow the local signs of synovitis, except that the effusion usually exceeds the synovial pouch limits. Local heat, pain, redness, and fluctuation, with marked loss of function are quite prominent, and atrophy of adjacent muscles is usually an early manifestation. The constitutional signs of sepsis (fever, increased pulse, chills, sweats, prostration) may be mild or severe, depending upon the invading organism and the extent of involvement. Staphylococcus infection is the rule, and this may run a relatively slow course. Streptococcus infection is the exception, and runs a more rapid course. The gonococcus and the bacillus of tuberculosis, influenza, and typhoid are frequent originators.

Course and Prognosis.—The *acute* form tends to get well speedily and may leave no remnants. The *chronic* form may be slow and usually results in some demonstrable thickening, crepitus, adhesions, contractures, and occasionally atrophy. All these may exist to a con-

siderable degree without producing disability. The *purulent* form is serious and generally results in a damaged joint with more or less disability. Treatment modifies the outlook; and freedom from constitutional disease or infection often is a determining factor, as between a subsequent perfect and imperfect articulation.

Treatment.—*Acute Arthritis.*—The indications aim to provide (1) rest and immobilization; (2) restoration of function.

The first is attained by putting the joint at rest in a position to conserve the greatest function in the event of adhesions or ankylosis. The average case can be first treated by encircling the joint with cold moist gauze compresses wrung out of water, saline solution, lead and opium, or 50 per cent. alcohol. The limb is then elevated and held immobile by soft bandages or a light removable splint, extension being provided to keep the joint surfaces apart. To those who cannot stand cold, heat may be used after the same manner. Some cases respond well to extension and the use of an ice- or hot-water bag alone. After a time the local signs permit the use of gentle massage once daily, the joint afterward being wrapped in compresses wrung out of any of the above-named lotions. As soon as pain on massage lessens, some passive motion is used, and later active motion is increasingly allowed. At this stage immobilization in an adhesive plaster dressing or a light starch or plaster-of-Paris cast is agreeable. Such an immobilizing dressing should not be left unadjusted longer than a week, and preferably should be of a removable type to allow early massage. Some support must be given the joint until such time as moderate motion does not cause pain or swelling. Adhesions rarely form under early massage and passive motion; if they do occur, the methods mentioned below will aid in further restoring joint action.

Chronic arthritis being generally the outgrowth of the acute variety has to some extent the same treatment, especially if of the recurrent type. The main element is to prevent adhesions and undue atrophy; particular attention must be given extensor muscles, as they deteriorate faster than the flexors. Ichthyol ointment (10 to 50 per cent.) applied liberally on gauze is effective; iodin ointment (10 per cent.) or unguentum hydrargyri ammoniaci are also serviceable. Alternate douching with hot and cold water, followed by massage, is of prime value. Gradually increasing passive and active movements are to be urged. In the interval between treatments a splint or other retaining apparatus will be needed, and the limb must be kept in a position insuring greatest usefulness in the event of ankylosis. Baking, mechano-massage, vibration, and electricity all play a useful rôle. In *all forms*

of arthritis the systemic treatment must not be forgotten, and a suitable dietetic and hygienic regimen will be helpful. In the rheumatic and gouty much benefit will be derived from some such combination as:

℞. Kali iodidi ..... gr. v;
Vin. colch. rad. fl. ..... ♏v–xx;
Syr. sarsarp. co.
Aqua ..... āā q. s. ℥j.—M.
Sig.—One dram three or four times a day in water.

After pain and swelling have abated, an adhesive plaster, linen or rubber or woven bandage will be a comfort until joint strength is restored. This dressing can be removed at night.

Purulent (*septic*) *arthritis* must be treated actively by (1) extension, (2) incision, and (3) drainage. The incision should be made on a lateral dependent side of the joint, and in the majority of cases a general anesthetic will be necessary. The sites of incision for the main joints are indicated by the diagram. After the joint has been emptied by pressure a normal saline irrigation may be used to flush out the cavity; if the exit is not sufficient, a parallel incision will afford through-and-through escape of the fluid, but no irrigation should be made unless there is a free vent. *Drainage* should be free and by rubber (gutta-percha) tissue or fenestrated rubber tubing. If still the effusion has not a free outlet, further incisions must be made, and these are generally provided by enlarging the original incisions or by additional incisions to drain pus-pockets or hidden parts of the joint. Despite these, it may be necessary occasionally to lay the joint open and irrigate it with every part in full view and then to drain with the joint held widely apart (Fig. 59 shows this form of drainage in the knee-joint obtained by a semicircular incision below the patella—Mayo's method). Such a procedure may prevent excision or amputation. If the process does not yet abate, excision or amputation must be entertained, and the wisdom of either will depend in great part on the general condition of the patient; it is a hazardous alternative, but often saves life when all else has failed. In some cases the method of aspirating the pus via needle and the injection of some antiseptic is of value—the so-called "aspiration and injection" method. In this procedure the available pus is withdrawn, and then from a few drams to an ounce or more of the chosen antiseptic is introduced via the same needle, and then the needle is withdrawn and the part is encased in gauze and cotton and an extension splint is applied. A serous effusion generally follows, lasting a few days, and then the inflammation begins

to subside if the treatment is effective. Renewed aspiration and injection may follow if indicated. Two per cent. formalin in glycerin (prepared twenty-four hours in advance) is strongly recommended by the late John B. Murphy and others. Iodin or carbolic (1 : 20) are also used.

After the acute manifestations subside, adhesions, atrophy, and disability are to be overcome by the methods named in the foregoing. Joint damage is generally severe after purulent invasion and ankylosis is apt to occur, especially if the joint surfaces are not kept apart by extension.

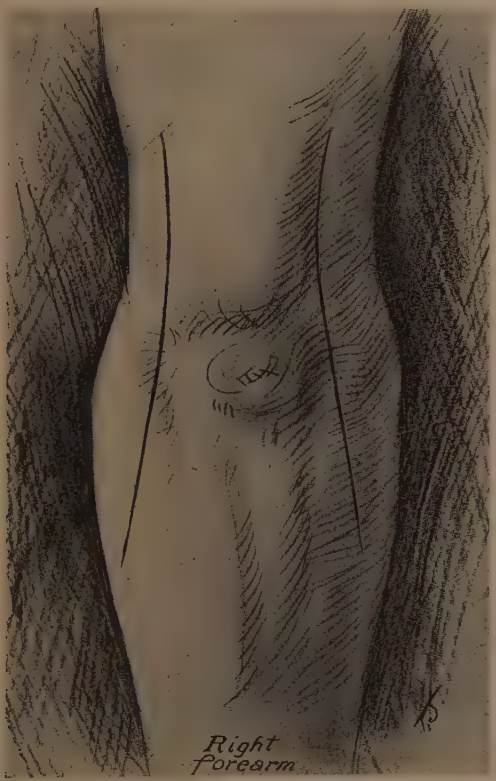


Fig. 95.—Posterior view of the right elbow, showing the location and direction of the two longitudinal incisions, one on the radial and one on the ulnar side of the olecranon (Murphy's Clinics).

Arthroplasty.[1]—The following series of illustrations (Figs. 95–102) show the steps in the late Dr. John B. Murphy's method of arthroplasty of the elbow for complete bony ankylosis between the humerus and ulna in a position of complete extension.

[1] The following illustrations (Figs. 95–118), with descriptive legends, were taken from the Clinics of John B. Murphy, Vol. III., Nos. 4 and 5.

Fig. 96.—Exposure of the capsule of the joint from the radial side. The positions of the humerus, radius, and ulna are indicated by dotted lines. Note the direction in which the curved chisel is applied to separate the bones on the radial side of the joint. Note also that the curve of the chisel selected for the division corresponds exactly to the normal curve of the articular surface of the elbow-joint, thus reproducing in the artificial joint the exact contour of the original (Murphy's Clinics).

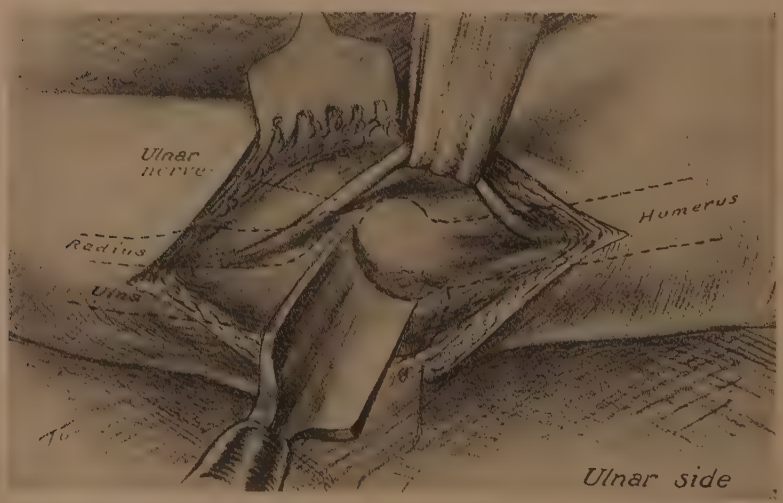


Fig. 97.—Exposure of the ulnar nerve and capsule of the joint from the ulnar side (Murphy's Clinics).

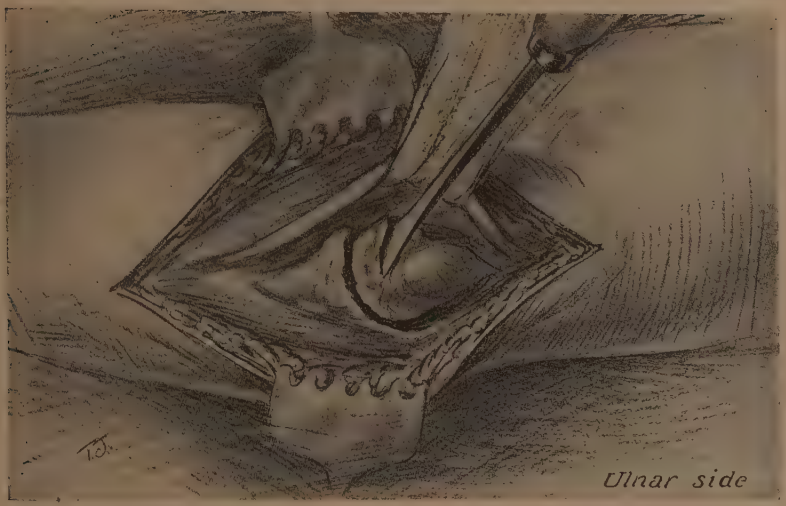


Fig. 98.—Removal of ulnar side of humerus (Murphy's Clinics).

Fig. 99.—Pedicled fat-and-fascia flap prepared from the outer side of the arm for insertion into the joint from the radial side (Murphy's Clinics).

Fig. 100.—Pedicled fat-and-fascia flap prepared from the inner surface of the forearm for insertion into the joint from the ulnar side (Murphy's Clinics).

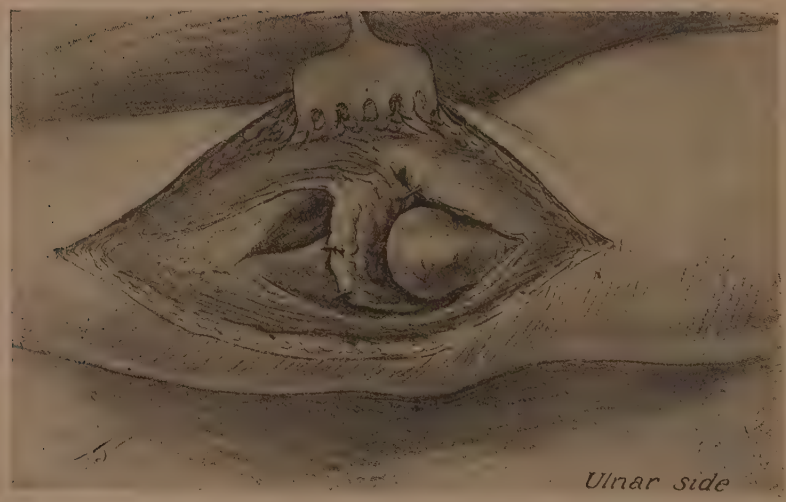


Fig. 101.—Ulnar flap interposed and sutured into position between the ulna and humerus (Murphy's Clinics).

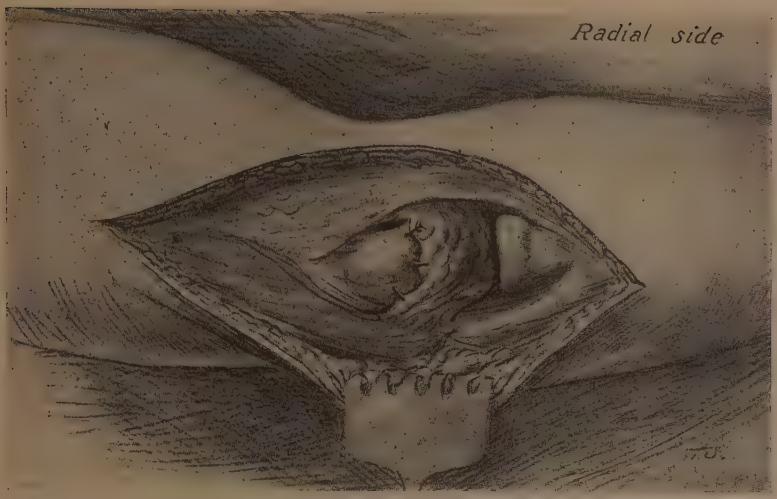


Fig. 102.—Radial flap interposed and sutured into position between the humerus and the radius and ulna. The deep stitches which fasten together the radial and ulnar flaps in the depths of the wound have not been shown in these illustrations (Murphy's Clinics).

The following series of illustrations (Figs. 103–110) show the essential steps in the late Dr. John B. Murphy's method of arthroplasty of the left hip by the fascia-and-fat flap method.

Fig. 103.—The essential steps in arthroplasty of the left hip by Dr. Murphy's fascia-and-fat flap method. "Goblet" incision through the skin and fascia lata down to the muscles and trochanter. The lower tip of the upper flap is placed just below the trochanter. The downward prolongation of the incision lies along the outer surface of the femur (Murphy's Clinics).

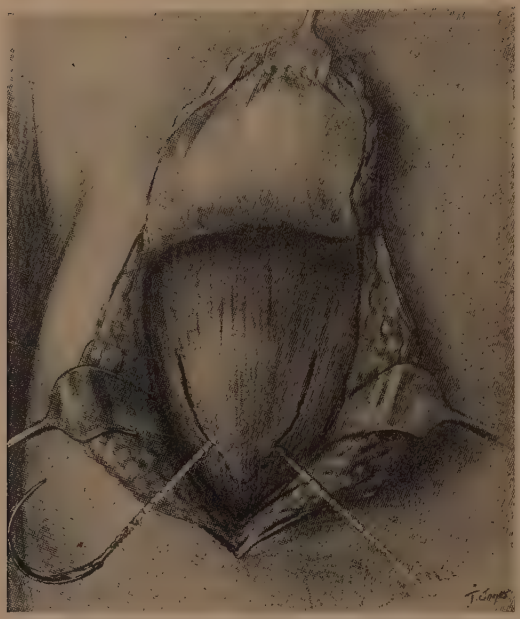


Fig. 104.—The flap of skin, fat, and fascia lata has been retracted upward; the anterior and posterior borders of the wound are retracted, thus exposing generously the great trochanter and its attached muscles. The chain-saw is passed on the needle underneath the superior muscle group, chiefly the gluteus medius, down to the capsule of the joint, and the trochanter with muscles attached is being sawed off in the direction indicated by the dotted line (Murphy's Clinics).

Fig. 105.—The trochanter with its attached muscles is drawn upward, the anterior fibers of the gluteus medius muscle having been cut. The capsule of the joint is being incised at right angles to the direction of its fibers. In this operation it was not necessary to cut either the pyriformis or obturator externus muscles (Murphy's Clinics).

Fig. 106.—The large gouge is being driven between the head of the femur and the acetabulum to divide the bony ankylosis between the two. Note that a gouge has been selected the curve of which fits the normal curve of the head of the femur and the acetabulum, so that the minimum amount of reshaping is necessary after the division of the ankylosis (Murphy's Clinics).

Fig. 107.—Reshaping and smoothing the head of the femur and the acetabular cavity with Dr. Murphy's end-mill and reamers. The head of the femur is dislocated backward from the acetabulum preceding this step of the operation (Murphy's Clinics).

Fig. 108.—Preparation from the under surface of the skin-flap of the Murphy pedicled fascia-and-fat flap for interposition between the freshened ends of the bones. The dotted lines indicate the extent of the flaps. The use of a pedicled and, therefore, viable flap of fascia and fat, interposed between the raw bony surfaces of the newly formed joint, is the characteristic feature of *all* arthroplasty operations (Murphy's Clinics).

Fig. 109.—The interposing pedicled flap of fascia and fat has been passed around the gluteus medius muscle posterior to its attachment, and dropped down over the acetabulum, to the rim of which it has been sutured with chromicized catgut. The head of the femur, when replaced, will lie on this flap (Murphy's Clinics).

Fig. 110.—The trochanter has been nailed back in place and the cut ends of the muscles sutured. Usually Dr. Murphy used a continuous suture of phosphor-bronze wire to reunite the muscles. The skin is sutured with horsehair and two or three tension sutures of silkworm-gut are inserted, if necessary (Murphy's Clinics).

The following series of illustrations (Figs. 111–118) show the steps in the late Dr. John B. Murphy's method of arthroplasty of the knee for bony ankylosis.

Fig. 111.—Internal and external curved incisions, giving free access to the knee-joint on both sides (Murphy's Clinics).

Fig. 112.—Freeing tibia from femur with curved chisel. Interposing flap prepared. Note that the curve of the chisel selected corresponds with the curve of the lower end of the femur. Although the pedicled fat-and-fascia flap was prepared in this case with its pedicle downward, it might as well have been prepared from the other direction (Murphy's Clinics).

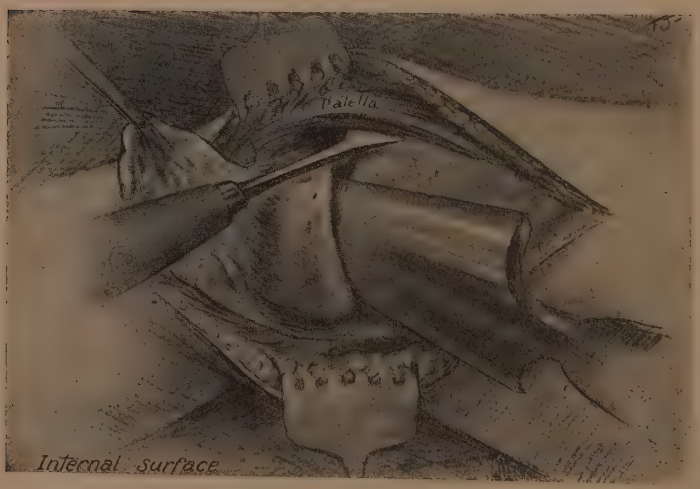


Fig. 113.—Freeing ankylosed patella from femur with "artist's" chisel. Interposing flap prepared. Freeing tibia from femur with curved chisel (Murphy's Clinics).

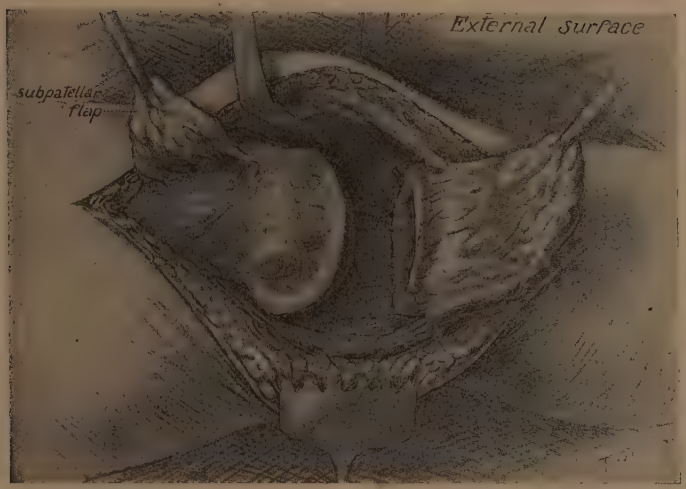


Fig. 114.—Articular surfaces of femur and tibia ready for insertion of interposing flap. Subpatellar flap prepared (Murphy's Clinics).

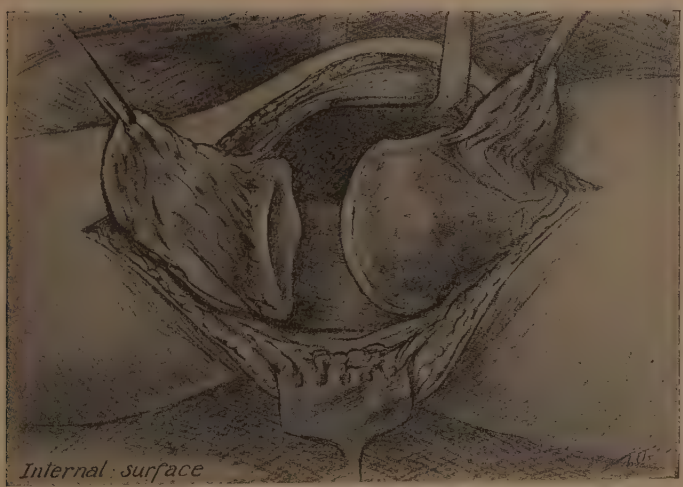


Fig. 115.—Articular surfaces of femur and tibia ready for insertion of interposing flaps. Internal subpatellar flap prepared. Note the width of the interarticular interval in the new joint—enough to accommodate the flaps easily, with something to spare (Murphy's Clinics).

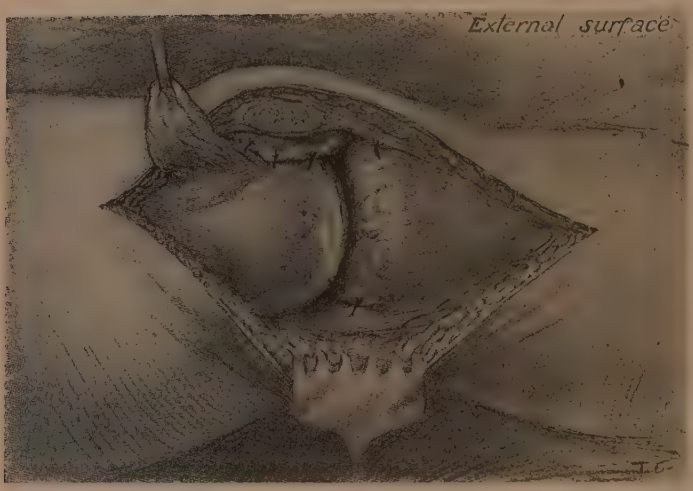


Fig. 116.—Shows external tibiofemoral flap inserted and outer edge of internal patellar flap sutured into place. External patellar flap prepared (Murphy's Clinics).

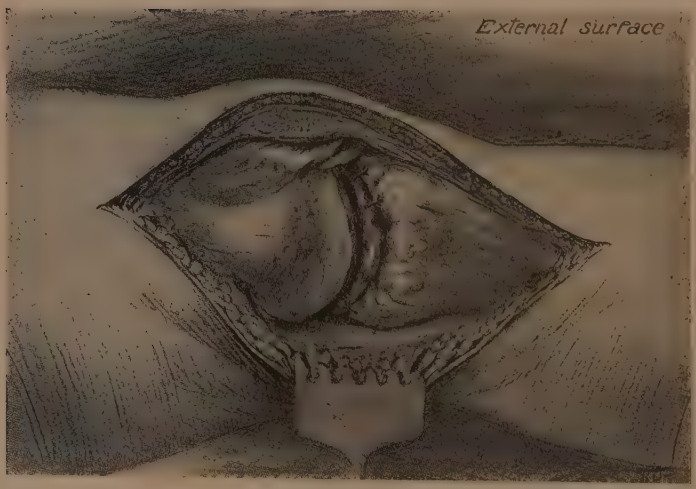


Fig. 117.—Shows the overlapping of internal and external interposing flaps (Murphy's Clinics).

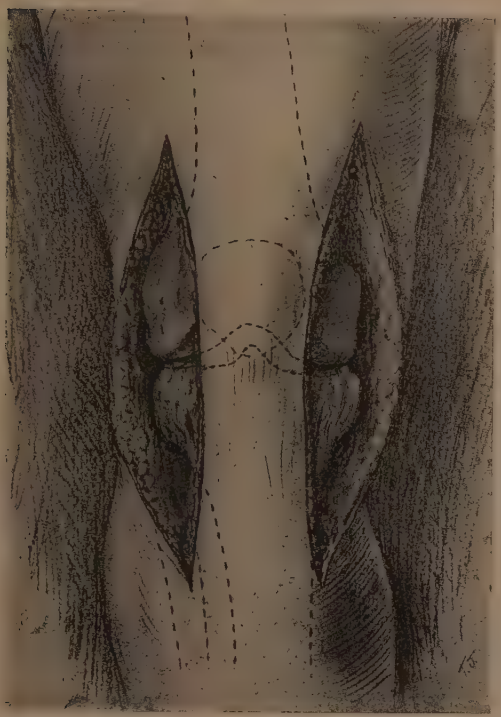


Fig. 118.—Schematic drawing showing the bone and anterior flap relations at completion of the operation (Murphy's Clinics).

SLIPPING CARTILAGE

This refers to the displacements occurring in the semilunar cartilages of the knee; the condition is also called "loose cartilage" and "Hey's internal derangement of the knee-joint" (Figs. 119, 120). In this country it seems a rare occurrence, but it is exceedingly common in England and Wales.

The internal cartilage enjoys some motion normally and is attached to the internal lateral ligament; but the external cartilage has no such arrangement.

Causes.—Generally it follows a sudden twist or wrench of the partly bent knee, the leg being at the same time slightly rotated outward. This causes strain on the inner side of the joint, and hence the internal cartilage is usually affected. It is said that displacement on the inner side is fifteen to twenty times more frequent than on the outer side. Running, a false step or jolt, athletics (notably football, tennis, and hurdling) are also provocative. Rarely is direct violence at fault.

Symptoms.—At the time of receipt severe sickening pain is often

felt, the patient usually falls, and the knee remains more or less bent or locked, and cannot be readily straightened. If seen promptly a marginal knob may be visible and palpable; if seen later, the accompanying synovitis and local tenderness may be the only evidence, especially if extension or manipulation of the joint has reduced the

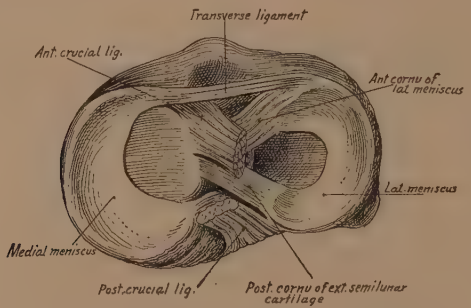


Fig. 119.—Semilunar cartilages of the knee.

deformity. Localized tenderness generally persists some time. In all cases synovitis occurs and the primary treatment practically resolves itself into caring for this.

The typical history is that of a knee injury followed by effusion and subsequent attacks in which the joint becomes "locked" in a bent

Fig. 120.—Varieties of semilunar cartilage injury.

position, manipulation being needed to straighten it. Each attack of "locking" induces re-effusion, and thus a recurrent synovitis pertains.

Treatment.—*Reduction* is generally easy by hyperflexion, pressure, and extension; in recurrent cases the patient will often volunteer to

"shake the knee into place." In primary cases anesthesia is usually needed. The synovitis is treated after the manner described for that condition. Care must be exercised later in bending the knee, and after the fluid subsides an adhesive or other support should be worn until tenderness and laxness subsides. In *recurrent* and *chronic* cases various knee-supporters are needed and much help comes from building up the inner side of the sole and heel of the shoes $\frac{1}{4}$ to $\frac{1}{2}$ inch, so that the weight is shifted more to the outer side. Massage is very valuable. "Shaffer's splint" and other allied apparatus are too cumbersome to be long used in comfort. If palliatives are inefficient, operative removal of part or all of the cartilage is advisable. The cartilage is exposed by a vertical incision (preferably after it has been dislocated), and then all or part of it is removed depending upon the extent to which it is fractured, fragmented, displaced, detached, or separated. Generally complete removal is the best procedure. The operation demands the maximum of asepsis and often considerable dexterity. Later an immobilizing splint is applied for two to four weeks, and thereafter massage and increasing motion is provided. The outcome is usually satisfactory.

CHAPTER V

DISLOCATIONS

Definition.—The displacement from each other of the articular ends of bones entering into the formation of a joint.

Varieties.—*Simple* or *closed* is the ordinary form, and in this there is no communicating break in the skin.

Compound or *open* is the form that communicates with the external air by means of a wound.

Complicated is one associated with a fracture of adjacent bones, or one with damage to neighboring soft parts.

Complete is one in which the articular surfaces are altogether separated or displaced so as to touch only at their edges; it is also called a *luxation*.

Incomplete is one in which the articular surfaces are only in part separated or displaced; it is also called a *subluxation*. This is a very rare condition and the best authorities doubt its occurrence.

Unreduced or *ancient* is one that has not been reduced or set.

Recurrent or *habitual* is one that recurs on slight provocation.

The name of the dislocation is derived from the bone furthest from the joint; as, for example, in hip-joint dislocation, we speak of dislocation of the upper end of the femur, and not of dislocation of the pelvis, or of dislocation of the upper end of the humerus, and not of the glenoid cavity of the scapula.

Frequency.—The shoulder is oftenest affected, providing nearly 90 per cent. of all; next in order are the elbow, ankle, knee, and wrist in so far as the main joints are concerned.

Causes.—*Age.*—Commonest in adult life; rare under ten years of age.

Sex.—Males more than females, in the proportion of 4 to 1; in dislocation of the lower jaw, however, the figures are reversed. *Injury* may act by (*a*) *direct violence*, as by a fall or blow imposed directly over the joint—a rare method; (*b*) *indirect violence*, as by a fall or blow transmitted to the joint from a distance—the commonest and ordinary method; (*c*) *muscular action*, as by a sudden muscular contraction or overstretching of muscle—a rare method and limited practically to the lower jaw, patella, and shoulder.

Certain so-called "loose jointed" persons can voluntarily produce some dislocations, notably at the thumb and other small joints.

There are certain so-called *pathologic, spontaneous*, and *congenital* dislocations that may also be mentioned for completeness only, inasmuch as they are non-traumatic in origin.

Pathology.—The chief damage is to the *capsule* of the joint, and this is always more or less stretched or torn. The *ligaments* and *muscles* may also be stretched or torn, but to a lesser degree than the capsule. The *nerves* and *blood-vessels* may also be involved either by tearing or pressure, and may give respective manifestations at once or later. The *bone* may be fractured and the *cartilage* may be separated or displaced. *Synovitis* is a regular accompaniment to some degree at least.

Symptoms.—These are (*a*) subjective and (*b*) objective. (*a*) *Subjective* symptoms relate to the history of injury (direct, indirect, or muscular violence) followed by *pain* and *disability*. Pain will depend on the location of the lesion, the manner of its receipt, and upon the individual. Disability will be complete and immediate in certain dislocations and individuals and less marked in other cases and persons. In many complete dislocations of main joints, pain will be great enough to impair or prevent function, and the disability will depend thereon and also upon the attendant deformity. Many patients will also recognize and complain of deformity, either due to the swelling or the distortion. (*b*) *Objective* symptoms are often so apparent and pathognomonic that the diagnosis is made at once.

Inspection discloses:

(*a*) *Deformity*, as shown by swelling or the reverse, and by malalignment in the contour or axis of the joint or limb. (*b*) *Discoloration* in the form of ecchymosis, often extensive and at a distance from the joint. This appears generally within an hour and may last months; in direct violence forms it comes on earlier and leaves sooner than in other forms.

Palpation discloses an abnormal prominence and the reverse about the contour of the joint, and tenderness and tension of the muscles and tendons adjacent. Crepitus may exist if effusion is present.

Motion discloses limited action, both actively and passively, with elicitation of pain and spasm of muscle and tension of tendons.

Measurement discloses shortening in the vertical and increase in the transverse axis of the limb.

x-Ray, fluoroscope, or radiograph discloses the actual condition; too much reliance cannot be placed on the former alone.

Figs. 121–135.

Main diagnostic reliance is to be placed on *deformity* (visible or palpable) and *lessened active* and *passive motion.*

Treatment.—The indications are to (1) *reduce* or *set;* (2) *immobilize* or *retain.*

(1) *Reduction* is to be done at once, bearing in mind that the articular end of the bone must be made to return in a reverse manner the route through which it has escaped from its normal habitat. This makes manipulation the key to treatment, and has resulted in the abandonment of forcible methods with or without special complicated apparatus. In muscular persons, in the timid or resistant, an anesthetic is given to the degree of muscular relaxation advisable. Chloroform *should never be used* for this purpose, because a dislocated or fractured bone seems to lessen resistance to this drug, even as pregnancy confers immunity upon it. As will be shown later, there are several means aside from anesthesia of inducing muscular relaxation, and these may be tried first if desired. Under no circumstances must undue force be used, and the physician will do well to first ascertain if any nerve damage exists, lest his manipulation is later accused of causing some neural or circulatory damage; this applies especially to shoulder dislocations. When the part is set, audible notice thereof is often apparent; proof positive is given by the increased range of motion that approaches or equals the normal. Under anesthesia the muscles will relax, but the tendons will remain tense until reduction.

(2) *Immobilization* need not be as complete or prolonged as in fractures, and all that is necessary is a sling, bandage, or *light* plaster-of-Paris dressing, to be worn not longer than ten days or two weeks. Thereafter it is removed, and massage twice daily for ten to thirty minutes is given for a week. The following week passive motion is added, and in the succeeding week active use is allowed. Under this plan restrictive adhesions are not likely to form; if they do arise, they are combated by the methods named in discussing synovitis and arthritis. In *compound dislocation* the wound is disinfected by tincture of iodin, used plentifully on as dry a surface as possible, so that the maximum of penetration may result. No hesitancy need arise about pouring or injecting the iodin into and about the wound and actually flooding the part with this drug. In practice this method has proved most satisfactory to me, and it is infinitely superior to the usual

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Figs. 121–135.—Whitman, "the joint thrower," assuming various dislocations of the shoulder- and hip-joints. This man is well known as a clinical exhibit, and has appeared many times at the author's Post-Graduate Hospital fracture clinic. Radiographs of some of these "dislocations" indicate that there is, in reality, no true bony separation.

scrubbing method. Oil or grease can be removed by turpentine, kerosene, olive oil, or gasolene. If the skin is ragged or undermined, or if torn fascia, muscle, or other soft parts protrude, it is wiser to enlarge the external opening and then to re-iodinize any fresh areas thus exposed. Suturing of soft parts is unwise except in very large openings; if done at all, the parts must be loosely coapted only. *Drainage should always be employed;* gutta-percha tissue folded or twisted acts well, either plain or in the form of a "cigarette drain." Rubber tubing with a strand of gauze passed through the lumen of the tube is also efficient. Gauze drains soon act as plugs and fail of their purpose. During the reductive manipulation of the dislocation, the wound is suitably protected by sterile gauze and a bandage or adhesive straps, and later a final dressing is reapplied. At the end of twenty-four to forty-eight hours the drain may be shortened or wholly removed if the wound shows no signs of infection and if the secretion is only serous in type. The wound edges may then with safety be further coapted by straps of sterile adhesive plaster; these can be readily improvised by heating "Z. O." adhesive over an alcohol or other flame. If infection occurs, treatment is given in accordance with that stated in discussing Infected Wounds. Complications arising demand appropriate treatment depending upon their nature.

If *fracture dislocation* exists it will often be impossible to correct both conditions without open operation; even then reduction may be very difficult. Trial should be made under anesthesia first, and if this fails, actual inspection through an incision is called for at once.

Nerve involvement may be due to the initial dislocation, to the manipulation leading to adjustment, or to pressure from the dressings. As previously stated, it is very important to recognize such a complication to forestall unjust criticism. Treatment for neuritis is accorded along the lines indicated in discussing Injuries to Nerves.

Blood-vessel involvement likewise may be an incident of the dislocation or of the reduction or treatment. Immediate recognition is essential, so that prompt incision may be made to prevent extensive bleeding that may prove disabling, if not fatal.

Prognosis.—With prompt recognition and treatment the outlook is good and functional return is the rule. This is notably true if early massage and use is insisted upon, as disability is directly proportionate to the extent of peri- and intra-articular adhesions. If the latter are kept from forming by joint activity, function is measurably restored when the rent in the capsule is healed and the stretched ligaments return to the normal; even in large joints this ordinarily occurs

within a few weeks. The outcome is not dependent directly upon the *dislocation*, but upon the intra- and extra-articular *adhesions* that form after reduction; this means that success in treatment depends upon early reduction and early use.

Special Dislocations

Upper Extremity.	*Lower Extremity.*
Lower jaw.	Hip.
Clavicle.	Sacro-iliac.
Ribs.	Coccyx.
Shoulder.	Knee.
Elbow.	Ankle.
Wrist.	Toes.
Fingers.	
Spine.	

LOWER JAW

Definition.—Separation of the condyle at the glenoid cavity (Fig. 137).

Causes.—Blows or falls upon the chin are less common sources of origin than laughing or yawning or attempts at chewing big morsels. It is very rare in the young because of lack of development of the

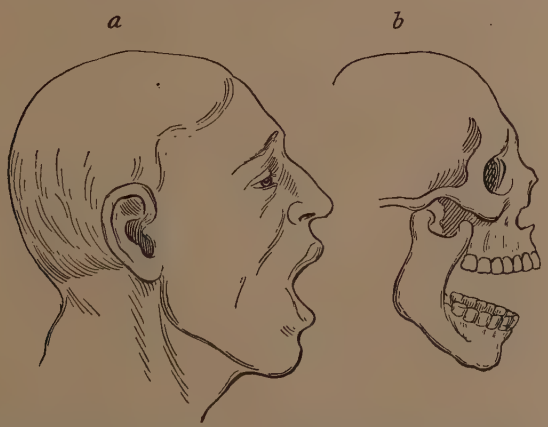


Fig. 136.—Dislocation of lower law: *a*, External appearance; *b*, internal appearance.

articular eminence in front of the condyle; it is more frequent in women because the condyle is smaller and has greater mobility.

Varieties.—(1) *Forward*, generally unilateral—the commonest form; (2) *backward*, rare and associated nearly always with fracture; (3) *outward*, clinical curiosity and only 4 cases are recorded; (4) *upward*, only 1 case on record. Bilateral forms are very rare (Figs. 137, 138).

Symptoms.—*Inspection.* –Jaws open; lower teeth and chin protrude; depression where condyle should be, in front of the ear.

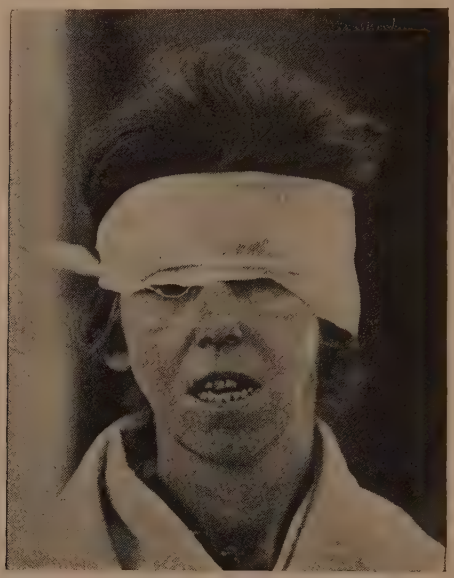


Fig. 137.—Bilateral dislocation of lower jaw.

Fig. 138.—Bilateral dislocation of lower jaw.

Palpation.—Condyle felt in abnormal position; socket of glenoid empty; muscles tense; pain. Foregoing verified by finger in mouth.

Motion lost; chewing action abolished.

Treatment.—For *reduction:* (1) Wrap thumb in gauze or handkerchief and press down and back on rear molars of lower jaw to disengage condyle, and at the same time use remaining fingers to lift up the point of the jaw; it goes back usually with a click or snap and the surgeon's fingers may be caught; (2) insert cork or cylinder of wood between molars and press point of jaw upward; (3) in old or resistant cases anesthesia or cutting operation may be needed; latter may require removal of condyle (Fig. 139).

Immobilizing.—Apply Barton's or other restraining bandage for two weeks and use liquid foods only. Stationers' or other wide rubber bands often act splendidly. Insist on caution in opening or shutting the jaw for several weeks. Pain will be felt at angles of jaw for some time, but this and the local swelling gradually subside. Many

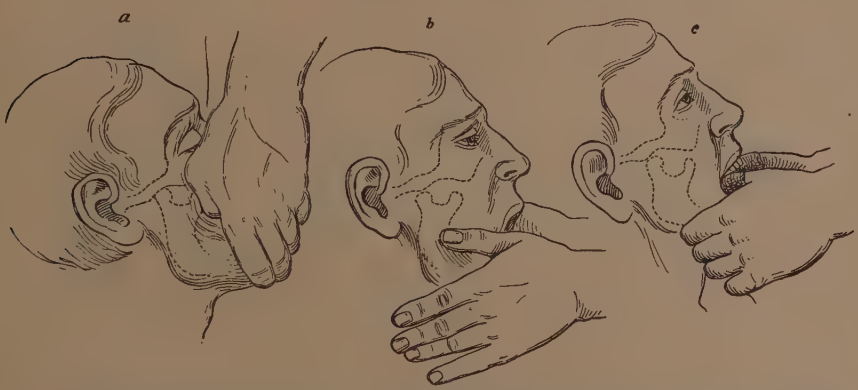


Fig. 139.—Three methods of reducing dislocation of lower jaw: *a*, Thumb pressure downward at molars, the other fingers lifting upward and forward; *b*, palm pressure downward and backward; *c*, gauze-covered thumb acting as in the first method.

patients say they get along just as well without any dressing whatever.

Results.—Recovery without deformity or disability is the rule. Working disability period two to four weeks.

CLAVICLE DISLOCATIONS

Separation may occur at the acromioclavicular (*outer end*) or sternoclavicular (*inner end*) joint (Figs. 140–143).

Varieties.—The *acromial* or *outer* end is oftenest dislocated; this can occur in three directions: (1) upward or supra-acromial (usual form); (2) downward and forward, or subcoracoid (rare); (3) downward and backward, or subacromial (very rare).

The *sternal* or *inner* end can be displaced in three directions also: (1) Forward (usual form); (2) upward (rare); (3) backward (very rare).

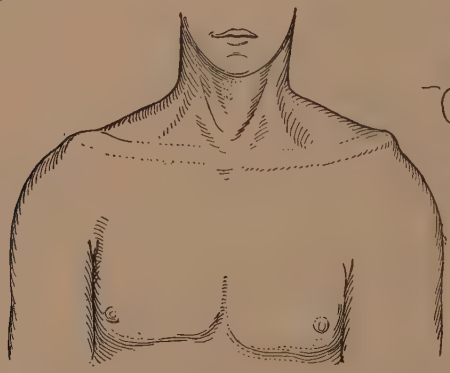


Fig. 140.—Dislocation of the outer end of the clavicle (acromioclavicular form).

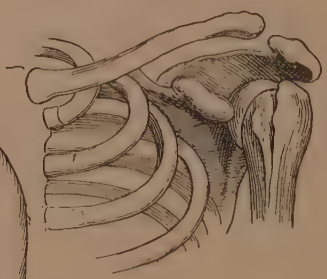


Fig. 141.—Same as Fig. 140, showing bony deformity.

Causes.—Both varieties follow indirect violence almost without exception, and generally a fall on the shoulder or outstretched hand or elbow is at fault. A blow over the joint or a crushing of the upper part of chest may rarely be productive. They also occur as an accompaniment of severe crushing injuries of the thorax or shoulder-

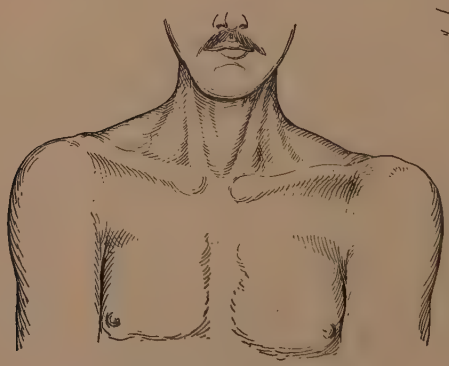


Fig. 142.—Dislocation of the inner end of the clavicle (sternoclavicular form).

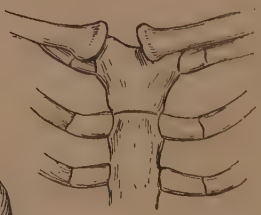


Fig. 143.—Same as Fig. 142, showing bony deformity.

girdle, usually in association with fractures of adjacent bones. Efforts at manipulation of a stiff shoulder exceptionally are also productive.

Symptoms.—*Inspection.*—Swelling over articulation (depression in the rarer forms); change in contour of upper chest or shoulder; arm held stiffly; ecchymosis usual.

Palpation.—Articular end abnormally prominent and movable, and it can be replaced but not retained by manipulation. Pain on pressure; joint crepitus rarely.

Motion of shoulder and arm impaired; respiratory efforts cautiously made.

Treatment.—*Reduction* is easily made by pressure over the joint from in front; or by drawing shoulders sharply backward and upward; practically the same maneuver as in setting a broken clavicle.

Immobilizing is more difficult, and it is rarely efficient enough to wholly prevent some enlargement. It is maintained by (1) a small pad of several folds of gauze over the joint, held there by criss-crossed straps of adhesive, and the arm is then held back by a shoulder spica

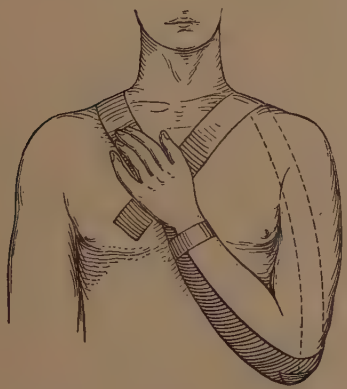


Fig. 144.—Adhesive strapping for sternoclavicular dislocation of the clavicle. Dotted lines indicate strapping for acromioclavicular dislocation of the clavicle.

Fig. 145.—Double shoulder spica for injury to sternal or acromial end of clavicle.

bandage. (2) A modified Sayre's dressing is comfortable and probably acts as well as anything. Figures 144 and 145 show adequate dressings. A pad in the axilla may be an aid in the acromial form. The dressing is worn for two to four weeks, some massage being given after ten days to prevent adhesive ankylosis of shoulder. Elevation of shoulder and similar motions should be interdicted for two or three months to prevent *recurrent* or *habitual dislocation*, which is not uncommon. In women, a prone position with a sand-bag or other weight over the joint for ten days or a fortnight offers the best prospect of freedom from deformity. Open operation designed to suture or remove the offending articular end should be reserved for that class of cases in which disability results from pressure or loss of shoulder-joint power, but

this is a very rare sequence. Some cases may well be treated by the "abduction method" advised by the author for the treatment of some forms of fractured clavicle.

Prognosis.—Some persisting deformity is the rule, with increase of motion and partial redislocation of the joint. Disability, even in the presence of a complete unreduced dislocation, is rare, owing to the anchoring afforded the joint and the whole clavicle by opposing muscles. Working disability period averages two to ten weeks.

RIB DISLOCATION

Separation of a rib may occur at the anterior (sternal) or posterior (vertebral) attachment.

Varieties.—At the *sternal* end the displacement can be: (1) Forward; usual form; (2) backward; rare; (3) vertical; very rare. In the eighth, ninth, and tenth rib the foregoing varieties occur at the costochondral junction. The fifth to the ninth ribs are oftenest involved; the sixth and seventh most commonly. At the *vertebral end* displacement is exceedingly rare and generally occurs with a fracture of an articular process of a vertebra.

Causes.—Ordinarily this is due to indirect violence, as by a fall, squeeze, or blow on the side of the chest, so that the main strain is transmitted to the attached ends, and the sternal articulation, being less firm, gives way. *Direct* violence, as by a blow, is scarcely ever at fault.

Symptoms.—*Inspection:* Knobbed swelling (or a depression) at the articulation; local swelling and ecchymosis sometimes. *Palpation:* Irregularity and motility are found; crepitus sometimes; pain. *Motion:* Free, and the deformity is generally reducible.

Treatment.—*Reduction* by pressure, deep breathing, straining, or coughing can generally be accomplished. *Immobilization* maintained by a 3-inch strap of adhesive passing over the dislocation from the middle of the back to beyond the center of chest; a second strap may overlap this 1 inch if needed. A pad of folded gauze over the articulation will afford more direct pressure if required. This is replaced after it gets loose (three to fourteen days) and some form of pressure is maintained three to four weeks. In that type associated with decided depression ("caving in"), open operation and elevation with suture or pinning may be necessary, but only if respiration is embarrassed or contour is much affected. *Complications:* Pleurisy rare; puncture of lung never occurs unless fracture or associated injury exists.

Results.—Deformity may persist; generally it tends to grow less

in time and is non-disabling. Pain on motion and weather changes subside usually after a few months.

Working disability period averages three to six weeks.

SHOULDER DISLOCATION

This refers to the displacement of the head of the humerus from the glenoid cavity. Over 50 per cent. of all dislocations occur in this joint (Fig. 146).

Anatomic Landmarks.—(1) *Acromion process*, especially the tip, is prominent enough to be ordinarily visible, and it can always be palpated even in a fat subject; (2) *coracoid process*, less likely to be felt in the presence of swelling or effusion; (3) *head of humerus*, visible often,

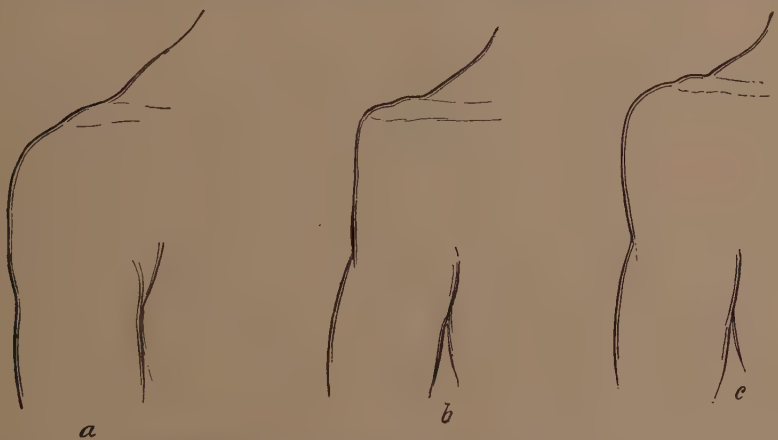


Fig. 146.—Shoulder contours: *a*, Normal rounding; *b*, depression in fractures of the upper arm; *c*, dislocation deformity.

and palpable either from summit of shoulder or by deep pressure in the cavity of the axilla; (4) *spur on clavicle* is occasionally enough developed to be apparent (Fig. 147).

Varieties.—Many are given, but the following six are clinical more than academic: (1) *Anterior* or *forward*: (*a*) *subcoracoid*—commonest; (*b*) *subclavicular*—second in frequency; (2) *downward:* (*a*) *subglenoid*—uncommon; (3) *posterior* or *backward:* (*a*) *subacromial*; (*b*) *subspinous* (both rare); (4) *upward:* (*a*) *supraglenoid*—clinical curiosity.

Causes.—*Direct violence*, as by a fall or blow directly upon the summit of the shoulder, is a common cause. *Indirect violence*, transmitted from a fall or blow on the elbow or hand, the arm being abducted at the time of the injury. *Muscular violence*, as in wrestling, throwing weights or a ball, and in tests of strength, accompanied by much ten-

sion of the upper arm and shoulder-girdle muscles. Of *all causes*, the commonest is a fall on the arm, elbow, or outstretched hand in an involuntary effort at protection.

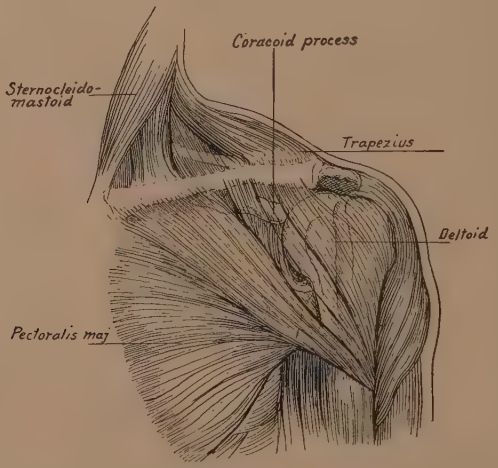


Fig. 147.—Structures about the shoulder-joint.

Pathology.—The head of the bone is shifted from its normal place through a tear in the joint capsule, this rent usually being in the antero-internal lower part of the ligament. Occasionally some of the

Fig. 148.—Dislocation of shoulder and fracture of greater tuberosity.

muscular fibers are also torn, notably the tendon of the subscapularis. Less often there may be some tearing of the infraspinatus, supraspinatus, teres minor, and long biceps tendon. The bony associated occasional damage is to the rim of the glenoid and the greater or lesser

tuberosity of the humerus (Fig. 148). The *vessels* in the axilla, vascular and neural, occasionally are also involved. The circumflex nerve is most often affected, although the whole brachial plexus sometimes suffers from stretching and occasionally from tearing. It is often questionable whether damage to vessels occurred from the injury or was due to efforts at reduction; frequently it is due to the latter or accompanies old or unreduced dislocations.

Symptoms.—The following general schema of signs is applicable here and in *all* dislocations.

Inspection.—Deformity, disability, discoloration. *Deformity:* As seen in the attitude of patient and limb; swelling. *Disability:* Function limited or abolished. *Discoloration:* Depends on when the patient is seen.

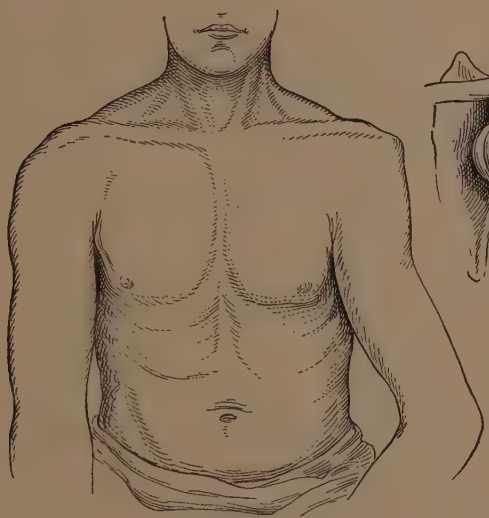


Fig. 149.—Subcoracoid dislocation of the shoulder.

Fig. 150.—Same as Fig. 149, showing bony deformity.

Palpation—Head of bone out of place; pain on pressure and motion; crepitation (sometimes unreliable); motion limited along normal axes.

Measurement.—Length of limb and joint diameter increased (Figs. 149, 150).

The other signs depend on the variety of dislocation, but the subcoracoid type only will be described in detail because this is *the* dislocation of the shoulder region and, indeed, of all other articulations.

Subcoracoid Symptoms.—Inspection.—(1) Deformity of patient's attitude as indicated by the diagram. The arm is kept from the side,

and often is held upward by the patient's uninjured hand, the face being tilted toward the damaged joint (Fig. 151). (2) Swelling or fulness shows in the front of the joint, with a hollowness and flatness over the region of the shoulder-cap at the deltoid area, and this visible change in joint contour can often best be noted by standing above and behind the seated patient and looking down upon the shoulders. (3) Axis of arm slants in toward the middle line, so that a line run along the lateral margins would strike well inside the joint. (4) Axillary fold level is altered. (5) Discoloration from ecchymosis ordinarily does

Fig. 151.—Double recurrent dislocation of shoulder (left unreduced). Patient was an epileptic who repeatedly dislocated the shoulders during his seizures.

not occur within the first few days, and may be quite extensive and take weeks to wholly disappear; but it is present to some degree in all cases. *Palpation:* (1) Head of the bone is out of the axilla; it can be located in front of the joint close to the coracoid and is felt to move by rotating the arm. (2) Pain is manifest on pressure and manipulation. (3) Elbow and inner arm cannot be brought to the side of chest, and hence the injured hand cannot be placed on opposite shoulder with the arm touching the side (Dugas' test). (4) Crepitation is unreliable, and if present, comes from effusion. (5) Function is abolished by pain and the false position. (6) The internal condyle lies in the same

axis as the middle of the head of the bone, and the external condyle in the axis of the greater tuberosity.

Measurement.—(1) Increase in length between the acromion and the external condyle; this may be slight. (2) Diameter of joint around the armpit is increased. The *main diagnostic signs* are practically visible, and chief reliance is to be placed upon (1) change in attitude of patient, his shoulder-summit and the axis of his arm, and the axillary fold level; (2) inability to make elbow touch side; (3) feeling a hole where a lump ought to be, and vice versa; (4) change in the vertical axis of the arm—*this is the best single sign* (Fig. 152).

Fig. 152.—Dislocation (subcoracoid) of the shoulder.

Treatment.—The indications are to (1) *reduce* or *set;* (2) *immobilize* or *retain;* and (3) *restore function.*

To *reduce* or *set,* manipulation is the best procedure, and this method should be repeatedly tried before traction or pressure is resorted to, inasmuch as the latter is exceedingly dangerous and relatively unscientific and not modern. Ordinarily no anesthetic is needed in a case seen within twenty-four hours; however, if the patient is resistant, very muscular, hypersensitive, or where an associated injury is suspected (as fracture of the surgical neck), it is then advisable to use an anesthetic. Chloroform, in my experience, is especially dangerous in

dislocation and fracture cases, and this perversity is just as inexplicable as its safety in obstetric practice. Nitrous oxid is the anesthetic of choice here; ether is the second choice, and ethyl chlorid the next best. Primary narcosis only is needed, and the patient is ready for the manipulation when he mixes up some test words when ordered to pronounce them; the words "truly rural" are usually used. The same preliminary safeguards must be used here as in any other case submitted to narcosis, because the very simplicity and speed of the operation occasionally leads to neglect of ordinary precautions. Especial caution is needed before anesthetizing a drunken patient. The sooner the reduction, the better.

The manipulation known as the *Kocher method* is the best because it is safest and surest. The patient has all the clothing removed to the waist line and is seated on a stool with both forearms resting on the knees; lying down positions answer as well. The subject is told what you are going to do and instructed not to resist, and also to forcibly expire when you so direct, as this somewhat diverts and prevents muscular contraction. In reducing a dislocated *right* shoulder the procedure is begun by allowing patient's elbow at a right angle to rest in the physician's left hand, the wrist of patient being loosely encircled by the right hand, and the following manipulations are then made (Figs. 153–156): (1) The elbow is brought as closely as possible to the patient's side; (2) rotation outward is slowly begun by keeping the elbow close to the side and *gradually* twisting the arm outward until the axis of the forearm is the same as the chest, or a little back of same. The head of the bone can be seen or felt (or both) to move with this procedure, and often it can be felt to slip into place—this is *the essential step*, and it must be done slowly and not jerkily. If the head of the bone does not rotate, stop at this point, and repeat the entire procedure again and again; (3) with the arm still rotated far outward, carry it forward, upward, and across the body—literally lift it up and in, so that it rests against the chest; (4) rotate arm inward and put hand on opposite shoulder.

The above steps are concisely said to consist of: (1) adduction; (2) external rotation; (3) elevation and adduction; (4) internal rotation.

Traction methods rely upon tiring out the muscles, thus preventing their contractile action. Of these, *Stimson's method* (Fig. 157) is the safest, and it is practised by making the patient place the side of the head on one table and the rest of his body on another, the injured arm hanging free between the tables. A hole cut in a cot answers the same purpose. A weight of 10 pounds is hung on the wrist or elbow, and

every few moments 10 pounds more are added until 40 pounds are attached; usually within fifteen minutes enough relaxation occurs to

Fig. 153.—Reduction of dislocation of shoulder (Kocher's method).

Fig. 154.—Adduction and external rotation; if necessary, this should continue until the chest and forearm are parallel.

Fig. 155.—Elevation and internal rotation.

Fig. 156.—Position of rest; incidentally this proves the reduction, as it is the application of "Dugas' test."

place the arm at the side, aided by a fist in the axilla to make upward pressure.

The *heel in or over axilla method* is mentioned only to be condemned, together with other forms of pressure-traction formerly employed. If, however, any such maneuvers are used, the axilla should be most carefully padded.

If reduction cannot be effected by the repeated trial of the Kocher or Stimson methods, an anesthetic is far safer than resort to any other procedure.

In old cases especially, it is important to determine the condition of the nerves so that no blame may come to the physician in the event of paralysis developing from the injury and not from the treatment.

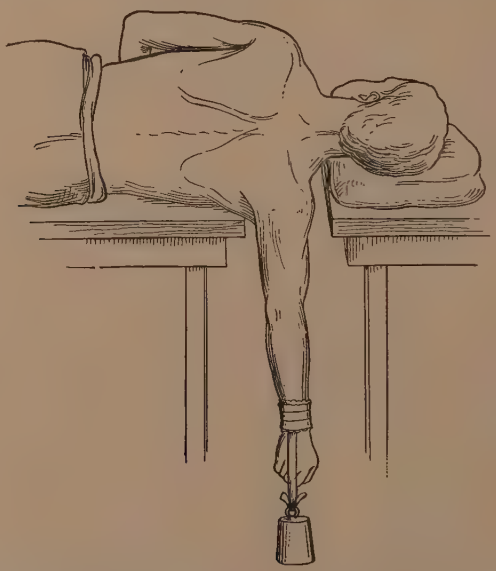


Fig. 157.—Stimson's method of reduction in shoulder dislocation.

Reference to the diagram will show the sensory distribution of the nerves oftenest affected.

The Dressing.—An adhesive plaster ("Z. O.") strap 3 inches wide is placed around the middle of the arm (so arranged as to permit two fingers to be introduced between it and the skin) and then drawn across the back and fastened just beyond the middle of the chest, a small folded pad of gauze being loosely placed in the axilla. A broad sling reaching from below the wrist to above the elbow completes the dressing. This may be modified by adding a 2-inch adhesive strap that begins at the middle of the clavicle, passes over the top of the shoulder, and hence down to pass around the elbow to the place of

beginning; the sling is also used with this. In some instances the typical Sayre's dressing (see Fracture of the Clavicle) is used. Dressings that completely encircle the shoulder are bulky and uncomfortable and have the added disadvantage of hiding the injured part. The Velpeau bandage and allied shoulder-caps are of this class. No initial dressing should remain on the part beyond two weeks; and from the beginning light daily massage over the joint (the adhesive dressing being in place) will promote absorption of the effusion, prevent adhesions, and restore muscle tone. Some passive motion after a week is allowable, with active motion beginning ten days later. After three weeks the adhesive or other dressing can be abandoned, and in a month the sling also. One group of surgeons recommends the use of a sling only, asserting that needed constriction will occur involuntarily from the splintage afforded by the contracting of the muscles if they are overused. If there is an associated fracture of a tuberosity, immobilization is maintained one week longer, but otherwise treatment is the same.

Result.—In all cases this has a decided bearing on the period of immobilization, and the longer and more complete this is, the more certain will be the prolonged stiffness. The joint enveloped in an immobile dressing for six weeks or longer scarcely ever regains full functional capacity within three months. The average case properly treated gets an excellent result and working power is restored in from two to ten weeks, depending upon the occupation. Pain is felt in the upper arm and in front of the joint for several weeks, and weather changes and overuse may aggravate it; but in time it disappears. The liability to recurrence is very rare and the "dislocation tendency" generally precedes and does not follow the initial dislocation. The motions last to be regained are circumduction and full abduction, but fortunately time and real effort do much toward perfect restoration. The average case gets well completely and the arm is ordinarily as good as ever.

Old or Unreduced Dislocations

These are cases of mistaken diagnosis, or lack of, or imperfect treatment, and many of them are self-treated or wholly disregarded.

Treatment.—If the head of the bone is not fixed, even though a period of several days or even weeks has elapsed, *cautious* trial of the Kocher or Stimson method may be successful. In cases of longer duration an anesthetic must always be used and every care employed to prevent damage to the vessels or fracture of the arm. Operation, in which the parts are exposed through an incision between the deltoid

Fig. 158.—Murphy's operation for recurring luxation of the shoulder-joint. Incision anterior to bicipital groove, through deltoid muscle, exposing the joint: *A*, Capsule split open; *B*, biceps tendon in bicipital groove; *C*, head of humerus (Clinics of Dr. John B. Murphy, Vol. IV, No. 5, October, 1915).

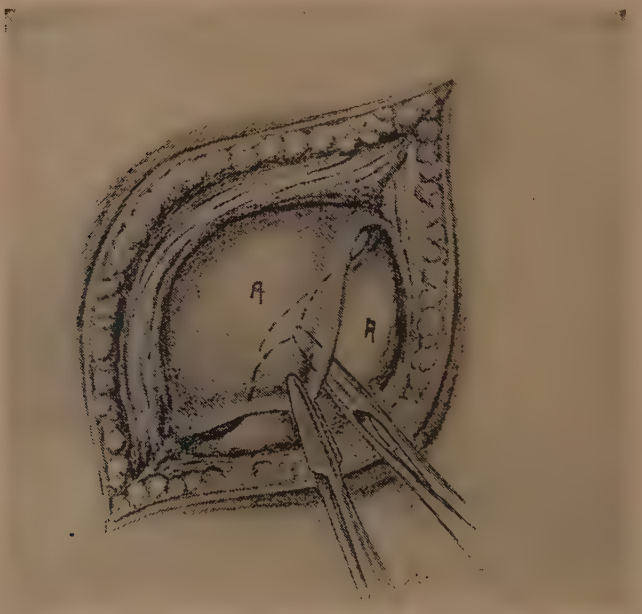


Fig. 159.—Overlapping or imbrication of capsule so as to reduce capsular tissue to desired amount, thus increasing retentive power, so as to prevent luxation of humerus (Clinics of Dr. John B. Murphy, Vol. IV, No. 5, October, 1915).

and the pectoral fibers, is in many cases the safest method. It may be necessary to remove the head of the bone if dense adhesions have formed and if the glenoid cavity is obliterated; excision should be avoided if possible because of the abduction disability induced. Proper postoperative treatment demands that massage and passive motion begin after a fortnight of immobilization.

Habitual or Recurrent Dislocation

This often requires the operation of "reefing the capsule" so that abnormal laxity of it is corrected (Figs. 158–160). Such patients

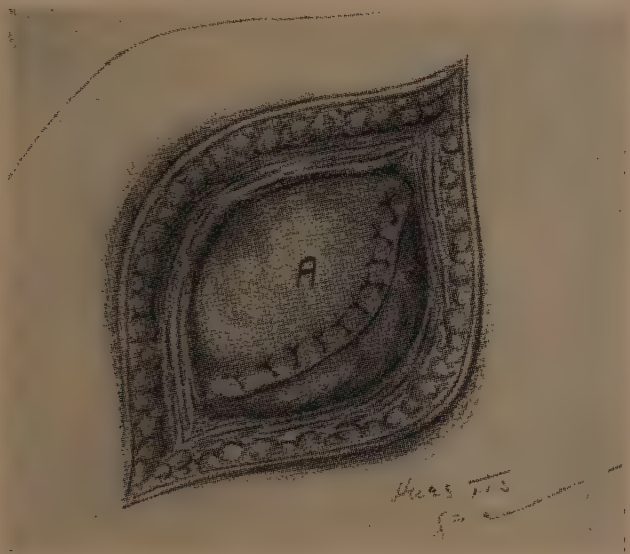


Fig. 160.—Capsule sutured, to be followed by usual closure of wound (Clinics of Dr. John B. Murphy, Vol. IV, No. 5, October, 1915)

should be cautioned against motions that unduly abduct the arm, and some apparatus may be devised and worn with this in view.

In any complicated case, as of suspected associated fracture, preliminary *x*-ray examination will be prudent.

Elbow Dislocation

This means the displacement of the bones of the forearm on the lower end of the arm bone (Fig. 161).

Varieties.—Backward; the commonest by far. Lateral; usually external and rather rare. Forward; very uncommon. A fracture is quite likely to be associated, especially with the backward variety.

Either bone alone of the forearm, especially the head of radius, may be dislocated (Figs. 162, 163).

Landmarks.—There are five about this joint; namely, the *olecranon*, *two epicondyles*, *head of radius*, and *front of shaft of humerus*. With

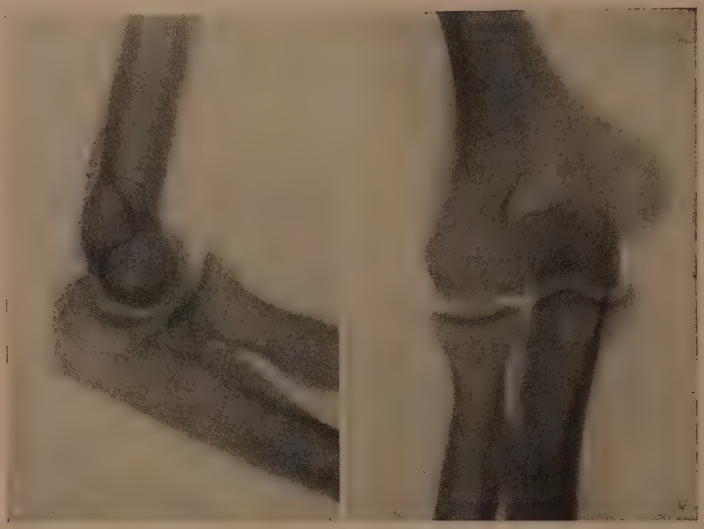


Fig. 161.—Normal elbow-joint.

the elbow straight, the tip of the olecranon and the tip of internal and external condyle are on the same straight line; with the elbow at a right angle, these three landmarks form a triangle. The head of radius can be felt to revolve just beneath the back part of external

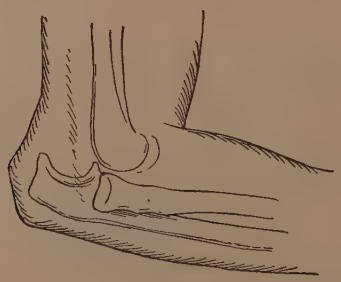


Fig. 162.—Backward dislocation of the elbow.

condyle. The shaft of the humerus is readily apparent. In the presence of even much swelling at least three of these landmarks can be identified, and massage will often render them still further palpable.

In examining an elbow (especially in children) most information will be gained by inspecting and palpating it from behind.

Causes.—Generally a fall on the hand or elbow with the latter joint partly flexed. Rarely a direct blow is causative.

Symptoms.—Those of any dislocation, notably the changed attitude and axis of the joint, and the fixed semiflexion and the prominence on the back part of the elbow.

The **diagnosis** is ordinarily apparent and if seen early there is often little swelling. A supracondyloid fracture is the only other condition presenting similar signs, but attention to the bony landmarks will differentiate promptly.

Treatment.—Reduction can be accomplished by (1) The extension and traction method; the forearm is extended and pulled down while the arm is steadied, and then the joint is flexed after the tension is

Fig. 163.—Backward dislocation of the elbow. Note avulsed flake of bone at under surface of humerus.

felt to relax. (2) Pressure on olecranon method: Standing back of the patient, two thumbs are pressed against the olecranon and the forearm forced down; especially good in recent cases and in children. (3) Sir Astley Cooper method: Pressure against lower forward end of humerus by surgeon's knee and slow forcible flexing of the forearm. The safest and surest method is to give primary anesthesia and then resort to one of the foregoing procedures.

After-treatment.—The elbow is kept quiet for two weeks in a light posterior right-angled splint, the parts not being wholly encircled or hidden; massage is then commenced and the splint discarded after three weeks and caution enjoined as to overaction, but use of the part is insisted upon. Very rarely there is some involvement of the ulnar, musculospiral, or median nerves.

Results.—Usually full restoration occurs, although for some weeks there may be pain and inability to put the joint through the full limits of motion. Genuine ankylosis is exceedingly rare (Fig. 164).

Fig. 164.—Dislocation of elbow (backward) with fracture at tip of olecranon; also fracture of lower third of radius and ulna. Patient (aged twelve) fell in a gymnasium; treatment instituted: reduction of dislocation under anesthesia; anteroposterior molded plaster-of-Paris splints from middle of arm to web of fingers, after reduction of fracture. Later, open operation and kangaroo tendon suture of radius for irremediable deformity; excellent result.

The other forms of elbow dislocation are of academic rather than practical interest and no further mention will, therefore, be made of them.

WRIST DISLOCATION

This means the displacement of the carpus upon the bones of the forearm. This is an exceedingly rare injury, and it is quite questionable if it ever occurs without fracture.

Landmarks of importance are: (1) Tip of styloid process of radius, about ½ to ¾ inch beneath (2) tip of the styloid of ulna, which also is

broader than the preceding; (3) depression between base of the thumb metacarpal and the radius—"the snuff-box": (4) base of the fifth metacarpal.

Varieties.—*Backward*, the usual form; *forward*, a clinical curiosity.

Causes.—Falls on the outstretched palm; rarely a direct blow.

Symptoms.—Those common to all dislocations, together with the attitude of the bent wrist and its changed axis. Where the deformity is not diagnostic, the altered position of the bony landmarks will be determinative. The great majority of cases first diagnosed as dislocations prove to be Colles' fractures (Fig. 165).

Treatment.—*Reduction* is made by flexion and traction; anesthesia is a valuable and often necessary aid. An anterior light splint is then applied, reaching from below the elbow to the web of the fingers, and the patient instructed to move the digits. This is removed after a week,

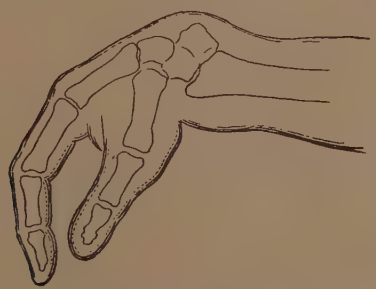


Fig. 165.—Backward dislocation of the wrist.

and then for two weeks an adhesive plaster or leather cuff can be used. Daily massage from the first is valuable. After three weeks, use of the part should be insisted upon.

Results.—An excellent outcome is assured if splintage is not prolonged; otherwise it may take some time to overcome adhesions.

CARPUS, METACARPUS, AND FINGER DISLOCATION

Carpal dislocation is exceedingly rare unaccompanied by fracture; the semilunar or os magnum are oftenest involved, usually from direct violence. Diagnosis from fracture often requires *x*-ray corroboration. Treatment is by pressure reduction and the application of a palmar splint, as in wrist dislocations. Operative removal may rarely be necessary; but persisting deformity does not entail disability.

Metacarpal dislocation is very rare except when the thumb is involved. This last occurs usually from a blow upon the thumb-knuckle, ordinarily received in fisticuffs.

The **symptoms** are obvious from the attitude of the wrist, the deformity of the thumb, and the ease with which the head of the bone slips about.

Treatment.—This consists of pressure-reduction and the use of an angled or gutter splint that keeps the thumb strongly abducted for three weeks at least. Flexion movements must be interdicted for some time thereafter to prevent recurrence.

Metacarpophalangeal Dislocation.—This typically occurs in the *thumb*, and in many instances is produced at will—the so-called "loose-

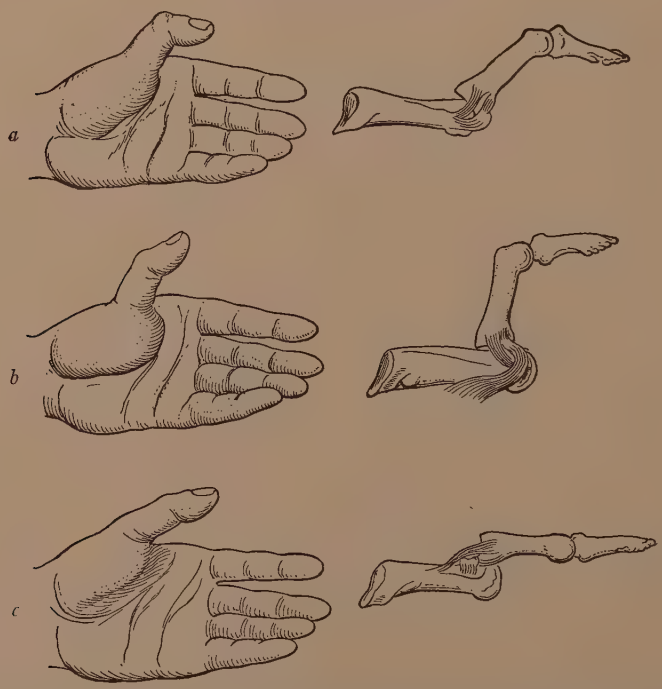


Fig. 166.—Three degrees of metacarpophalangeal dislocation of thumb: *a*, First degree; *b*, second degree; *c*, third degree.

jointed" person. The phalanx is dislocated backward on the metacarpus, usually from a fall, twist, or blow that produces hyperextension of the thumb. It may appear in three degrees: *first*, where the phalanx is at an acute angle; *second*, where the phalanx remains hyperextended and stands out at right angles to the palm; *third*, where the phalanx has been partly reduced so that it lies parallel to the palm (Fig. 166).

Treatment.—This is manipulative, so that the joint is relaxed and the interposed torn capsule, flexors, and tendons are released (Fig. 167). This

Fig. 167.—Steps in reduction of metacarpophalangeal dislocation of thumb: *a*, Abduction or hyperextension; *b*, dorsal flexion and downward pressure; *c*, traction and adduction.

is accomplished by seeking to (1) hyperextend the thumb so that it is bent far backward; (2) push the base of the thumb downward toward

Fig. 168.—Dislocation of last joint of little finger (antero-external form).

its socket—pulling motions defeat this; (3) direct traction and adduction. A gliding or rotatory rocking motion helps in these maneuvers;

a *b* *c*

Fig. 169.—Dislocation of phalanx: *a*, Incomplete dislocation (cross-section); *b*, complete dislocation (cross-section); *c*, complete dislocation (cross-section).

many attempts may be needed, and sometimes open operation is required. *After-treatment* is light splintage for two or three weeks,

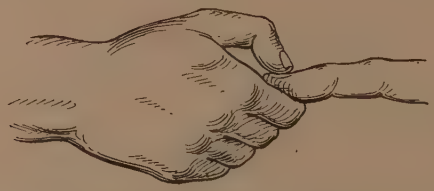


Fig. 170.—Extension grip for reduction of a dislocation or fracture of a phalanx.

followed by moderate but increasing use. Considerable thickening and some limited motion is not unlikely to persist.

Finger dislocation is commonest in the distal joint and occurs from a blow, fall, or twist, a backward dislocation being usual (Figs. 168, 169).

Symptoms are obvious; care must be taken to exclude fracture.

Treatment.—Reduction is by traction, pressure, or manipulation (Fig. 170). A light palmar finger splint (like a wooden tongue depressor) is used for a few days, and then increasing use is advisable.

SPINE DISLOCATION

Definition.—The displacement of one vertebra upon another, the superior slipping over the inferior. It is very commonly an associate of fracture, the so-called fracture-dislocation of the spine. Injury above the fourth cervical vertebra is generally immediately fatal and, therefore, little will be stated about these unfortunate forms.

Landmarks.—*Spinous processes* are visible and palpable almost constantly, although their vertical and lateral axes are rarely uniform or symmetric. The seventh cervical spine (vertebra prominens) is the most visible landmark in the upper segment; but the first dorsal spine is not infrequently a "prominens" instead. The spines of the atlas and axis are frequently palpable. The body of the fourth lumbar vertebra is on a level with the crest of the ilium. *Transverse processes* are palpable in certain areas, notably near central part of the sternomastoid muscle. *Intervertebral bodies* are palpable as far as the fourth disk.

It is not to be forgotten that the spine presents many normal irregularities, and too great reliance is not to be placed on the presence of these unless the deviation is marked or accompanied by commensurate symptoms.

Varieties.—(1) *Forward*, either of the (*a*) entire vertebra or (*b*) a lateral process; (2) *backward*, the above reversed—rare; (3) *lateral* and *rotatory*—very rare; (4) *diastasis* or *distortion*, where there is little if any displacement and the damage is to the soft parts and to the stretched cord; this form occurs only in the cervical region and is limited almost always to the fifth or sixth vertebra, and is associated with hematomyelia and symptoms of root or nerve pressure.

Pathology.—*Hard parts:* The *bodies* or *arches* (or both) are out of place. There may be a slipping of the *cartilaginous* or *bony* parts. *Soft parts:* The interspinous *ligaments* are stretched or torn; the *muscles* may similarly suffer. The *blood-vessels* may be more or less torn, resulting in extra- or intraspinal bleeding. The *nerve-roots* or *fibers* may be bruised, crushed, or torn. The *dura* may be bruised or

torn, leading to escape of cerebrospinal fluid. The *cord* may be bruised, crushed, or torn, and the laceration may even involve the white matter. The lesions thus may vary from ordinary sprain to complete cord destruction, depending upon (*a*) the location and (*b*) the extent of the damage.

Causes.—*Direct violence* rarely originates, as from a blow, fall, or twist. *Indirect violence* commonly is at fault, like severe forward or backward bending motions; thus any severe trauma imposing the so-called "jack-knife" position may be causative. Of these, may be mentioned such incidents as diving, jamming between moving objects (as an elevator and flooring), or objects striking the back while the patient is stooping. *Muscular violence* very occasionally may cause some of the minor forms.

Symptoms.—These depend upon (*a*) site and (*b*) extent of the trauma.

Fig. 171.—Dislocation of axis.

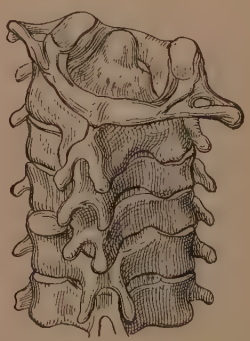


Fig. 172.—Dislocation of atlas and axis.

Region of the Four Upper Cervical Spines.—With any considerable dislocation in this area death is usually instantaneous (Figs. 171, 172). Where the displacement is only partial the signs are: (1) *Deformity*—the head is tilted forward and downward, or laterally; the neck muscles are tense and prominent and their outline is changed. There may be ecchymosis or some local visible injury. (2) *Palpation* shows rigidity of the neck muscles or local tenderness. Bony irregularity may be palpable in the upper neck or in the pharynx. The head often hangs loosely and "flops" about, seeking to rest on the chin. Sensory tests may elicit signs of injury to the occipitalis major or minor, the auriculotemporal, the superficialis colli, or auricularis magnus nerves. (3) *Cord*

damage of varying extent may exist, giving appropriate trophic, motor, and sensory signs (Figs. 173, 174).

Fig. 173.—Typical deformity in dislocation of cervical spine.

Fig. 174.—Deformity in forward dislocation of the upper cervical vertebræ.

Treatment.—This depends upon the extent of the apparent damage; all the factors must be carefully considered, as attempts at reduc-

Fig. 175.—Dislocation of cervical vertebra, showing a method of manual traction.

tion occasionally have caused death. Open operation (for visible reduction or laminectomy) are generally contra-indicated. The *minor degree* cases are best treated by a supine position with a sand-

bag under the shoulder and traction of the head from a support under the chin, reaching thence over the head and ears. Later a leather, plaster-of-Paris, or Thomas collar is worn. *Severer* cases require traction and bending back of head, the surgeon directing the extent of this by palpating the part through the neck and the pharynx. This sort of manipulation must be slow, steady, and well planned, with capable assistance. Later a neck support is worn, and is often needed for a long time.

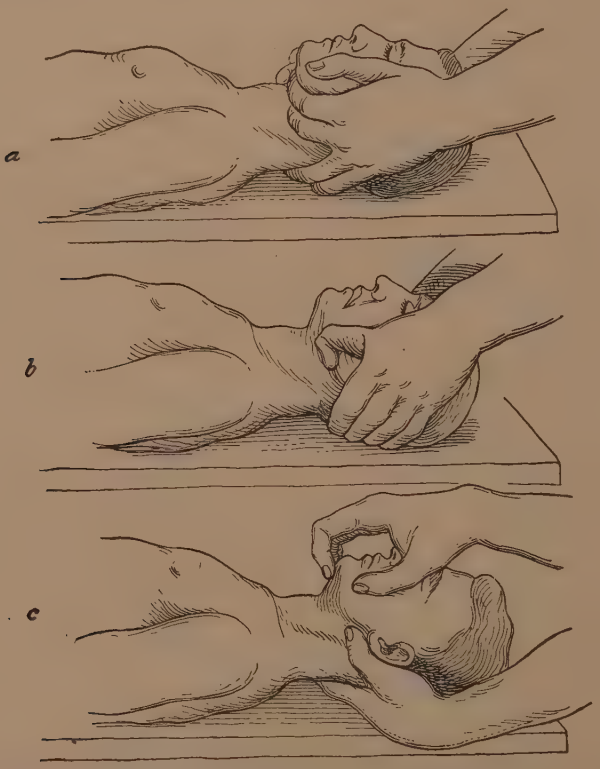


Fig. 176.—Manual traction methods in dislocation of the cervical vertebræ: *a*, Direct traction; *b*, traction and flexion; *c*, traction and extension.

It is generally safer to attempt reduction rather than to run the risk of an immediate fatality from spontaneous sudden increase of deformity inducing cord pressure. No anesthetic should be used if possible (Figs. 175, 176). Preliminary *x*-ray examination is extremely valuable, but unfortunately in the highest levels the plates may not be very clear. Any treatment should be prompt to be effective; but even after a lapse of two months successful reduction has been accomplished.

Much attention should be given the patient's general condition to prevent bed-sores, ascending urinary infections, pneumonia, and similar later liabilities. The water-bed is a valuable adjunct and a skilled nurse an essential.

Region of the Lower Cervical Spine.—Typical uncomplicated dislocations occur in the cervical segment below the fourth cervical level oftener than in any other part of the spine because of the normal mobility, the absence of rib articulations, and the shape of the bony processes. The fifth, sixth, and seventh vertebræ are oftenest affected.

Varieties are similar to those named hitherto; the forward complete or incomplete types are the commonest.

Symptoms.—These depend on the site and extent of the damage, as hitherto indicated. The tilting of the head is quite marked; if the luxation is on the right, the head is turned toward the left, and vice versa (Fig. 177). *Bony irregularity*, spasm of muscle, and local ten-

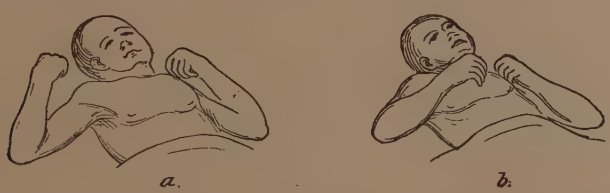


Fig. 177.—Deformity in fracture-dislocation of the lower cervical vertebræ: *a*, Injury of the fifth and sixth segments; *b*, injury of the sixth and seventh segments (after Thorburn).

derness may be marked. Pressure signs of brachial plexus involvement may be present, especially in the unilateral forms.

Treatment.—Reduction by traction and manipulation is fortunately usually easy of accomplishment. An anesthetic is advisable. The surgeon should not undertake the procedure without informing the patient or his relatives of the possibility of an immediate fatal outcome. Traction is best made by placing the left hand over the mouth so that the fingers hook under the chin, the right hand making traction and supporting the head from beneath the occiput. Direct traction may also be made by pressure upward against the angle of the jaw. If reduction is successful, the deformity is seen and felt to disappear at once; occasionally it is audible.

After-treatment requires the use of sand-bags to prevent movements or a plaster-of-Paris collar for several weeks, and later a lighter similar support is to be worn until pain on motion disappears.

Region of the Dorsal Spines.—Dislocation here rarely occurs with-

out fracture; the last three vertebræ are oftenest affected, the twelfth especially. It is said that, experimentally, dislocation cannot be produced below the fifth dorsal spine (Keen's *Surgery*, Vol. II, p. 875).

Varieties.—The forward, unilateral, or bilateral type is usual, inasmuch as the producing cause is generally a "jack-knifing" force causing a sharp bending forward of the body (Fig. 178).

Symptoms.—These depend on the site and extent of the injury. Deformity is generally obvious in the bent or arched condition of the back, with or without kyphos or abnormal lateral deviation. There may be a hematoma or other local signs of injury, and the late occurrence of circumscribed ecchymosis is very suggestive in the absence of contusion signs. Pain on pressure is marked, and disability is usually complete, either from pain alone or paralysis. Nerve damage may vary from complete paralysis below the lesion to localized areas of altered sensation. The *initial* extent of the paralysis is no positive measure of the amount or degree of the cord damage. Pressure from effused blood may be great enough to abolish all cord sensation even though the latter is intact; for this reason a very guarded outlook must be given, especially when the patient is seen early.

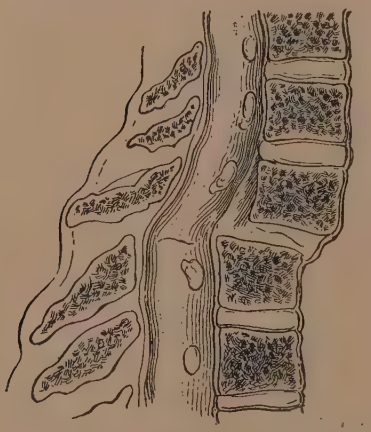


Fig. 178,—Dislocation of spine (forward variety) with angulation and constriction of the spinal cord.

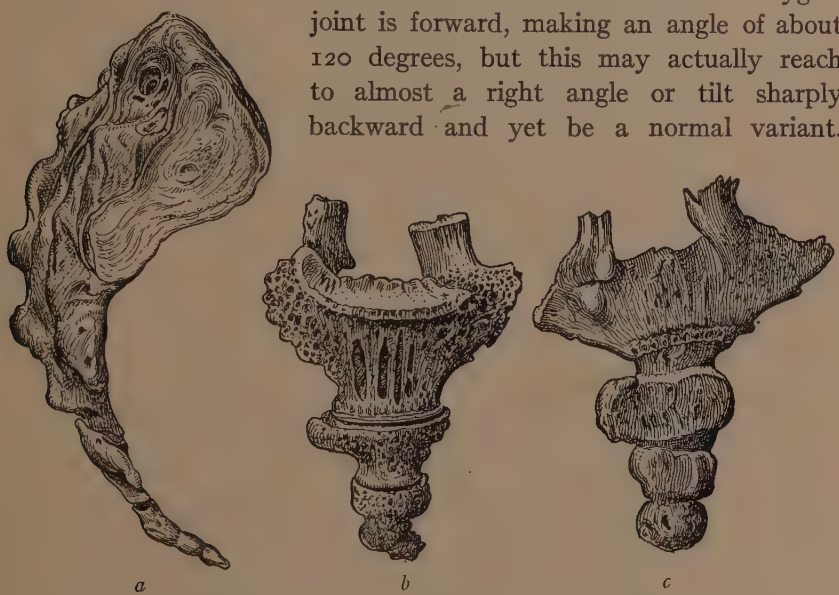
The signs corresponding to cord injury at various levels will be discussed under Fracture of the Dorsal Spine, because the symptoms are practically identical, as fracture and dislocation generally coexist.

Treatment.—Reduction by traction and pressure with the patient anesthetized has been successful, but the usual treatment in the non-paralyzed cases is to apply a plaster-of-Paris jacket after full extension has been obtained. If, however, there is pain from pressure and apparent danger of increase of deformity, the patient is to be placed on a Bradford frame or similar device, and gradual pressure made on the spine just lateral to the site of the deformity. Gradually increasing pressure of this sort sometimes removes the kyphos, and then a plaster-of-Paris jacket can be worn. Open reduction, by laminectomy or otherwise, is reserved for those cases that fail to respond to other measures.

Region of the Lumbar and Sacral Spines.—These dislocations do not occur as entities. (See Sacro-iliac Dislocation.)

Region of the Coccyx.—This dislocation is very rarely heard of in civil practice, but is a common allegation in personal injury claims and suits. The writer has had but one genuine case in his own personal experience, but has examined scores of cases in which it was claimed but never found.

Anatomy.—This rudimentary triangular bone is made up of four segments, the distal three generally uniting to form one. The total length is about 2 inches, the upper width is about 1 inch (Fig. 179). The normal direction at the sacrococcygeal joint is forward, making an angle of about 120 degrees, but this may actually reach to almost a right angle or tilt sharply backward and yet be a normal variant.



a *b* *c*

Fig. 179.—*a*, Sacrum and coccyx, lateral view; *b*, coccyx, posterior view; *c*, coccyx, anterior view.

The sacrococcygeal ligament is strong but elastic, and allows considerable motion within functional limits, and that this must be so is apparent from the proximity of the rectum, which constantly exerts varying pressure. In women the normal position and mobility is more marked because of the difference in the shape of the pelvis for obstetric purposes. The levator ani (in front), the sphincter ani (at apex), the gluteus maximus (in back), and the coccygeus (laterally) are the attached important muscles of this region, and in real injury to the bone their action should be limited or abolished. Until about the twentieth year there is more or less motion between the segments com-

posing the bone, the second and third being the last to fully ossify and unite. At about the age of fifty union or complete ossification at the sacrococcygeal joint usually occurs; it may be earlier or later and is one of the articular and other senile changes noted at this period.

Inasmuch as the spinal canal does not extend beyond the first lumbar vertebra, the nerves about the coccyx are only filaments of the cauda equina, which latter begins at the lower border of the first lumbar vertebræ, and this is distant some 6 or 8 inches from the beginning of the coccyx.

Causes.—Direct violence is obviously the only traumatic producing factor, and this may occur from a fall so that the parts between the folds of the buttocks impinge upon a raised object. For that reason falls astride chairs, fences, or pointed objects may be causative; kicks

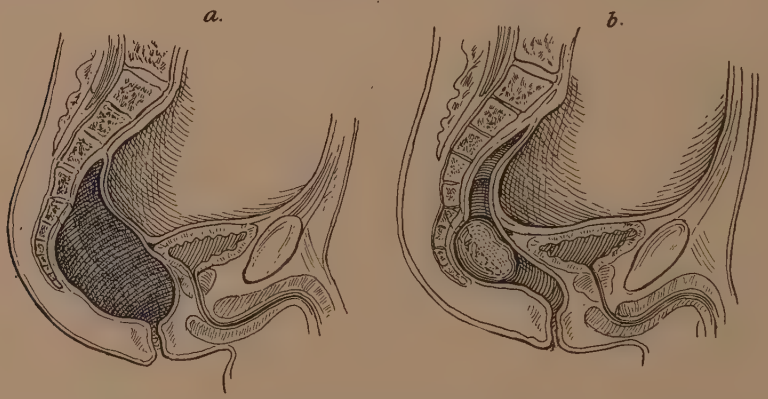


Fig. 180.—Coccyx and alterations in its axis by pressure from within: *a*, Displacement due to a full rectum; *b*, displacement due to a tumor.

or severe blows occasionally are the injuring force. No fall on the buttocks or back nor any form of *indirect* violence is likely to cause damage because of the intervening protection. From pressure within the pelvis (as in parturition) dislocation has also occurred (Fig. 180). Likewise, consequent to pelvic, rheumatic, or other inflammation, an abnormally fixed position may be produced, but this may not be discovered until rectal or vaginal examination is made, as in this type of case other lesions are more prominent.

Varieties.—*Forward*, the commonest sort (Fig. 181); *backward*, from pressure within, as in pregnancy; *lateral*, exceedinly rare; only one genuine reported case is on record (Stimson).

Symptoms.—*Pain* is the most prominent, and it is especially marked at the time the violence is sustained and is usually severe enough to

completely disable. Later it is induced by motions that drag on the attached muscles; hence sitting, standing, and walking are carried on with effort. Defecation is especially painful and there is often frequent desire to urinate, with dysuria. There may also be some bloody discharge from the vagina or rectum.

Fig. 181.—Fracture-dislocation of the coccyx. This is the only radiograph of the sort the author has ever seen.

Examination shows an attitude assumed to relieve direct pressure and muscle pull, and such patients sit on the edge of the chair or use "a ring" or air cushion. Early there may be ecchymosis or contusion signs directly over the coccyx. Pain on pressure is prominent and crepitus and false motion may be elicited from without or within. All movement, especially abduction of the thigh, increases the pain. *Rectally* or *vaginally* there is local tenderness on pressure, and the

bone then is found in an exaggerated motile position, and when it is returned to the normal (usually pushed backward) there is consider-

Fig. 182.—Sacro-iliac separation, anterior view (by courtesy of Dr. Lewis G. Cole).

Fig. 183.—Sacro-iliac separation, posterior view (by courtesy of Dr. Lewis G. Cole).

able relief from pain. There may be crepitus. If seen after reduction, the history of the case (*i. e.*, manner of accident, immediate and subsequent symptoms, and treatment) must be carefully considered

before a diagnosis of contusion of soft parts or coccygodynia is excluded. If the history does not accord with that of dislocation, and if there are other signs of pelvic, rectal, or neurotic disturbance, and no verifiable physical evidences of injury, then the case is not one primarily originating directly from an injured coccyx. Certainly from a clinical standpoint the condition is one of great rarity.

Treatment.—Reduction should be made at once bidigitally, with the index-finger introduced into the rectum or vagina, the thumb being in the internatal fold. This will be painful for an instant, but relief from this procedure is prompt. A soft-rubber tube (1 inch in diameter) wrapped in a piece of oiled iodoform gauze is then to be inserted 3 to 6 inches into the rectum and left there three or four days. The gauze may then be removed, allowing the tube to remain *in situ*, the bowels being moved on the fifth or sixth day by cathartics. Packing the vagina with gauze may prove an aid to the rectal splint; this should be removed on the third day. A gauze plugging of the rectum may be preferred. A rubber ring or air cushion support is essential, and a broad strap of adhesive about the hips may help to limit muscular action. The patient can walk about as soon as desired.

The mental effect produced in such a case by referring to it as a "spinal injury" should induce the cautious physician to refrain from such remarks in the patient's presence, especially as this phrase has no real surgical or anatomic warrant.

HIP DISLOCATION

This is a very rare form of injury, especially in those over forty-five years of age, as patients at that time of life generally sustain fractures of the femoral neck by violence which in a younger person might induce luxation.

Landmarks.—*Spines: Anterior superior*, palpable even in the very fat. *Posterior superior*, sometimes hard to fix. *Pubic*, found even in a fat subject by straddling the *pubic symphysis* with the thumb and forefinger. *Tuberosity: Ischial*, usually found by deep pressure and everting the internatal groove. *Great trochanter*, often visible in outline and ordinarily palpable.

Causes.—*Direct violence* is rarely at fault, such as a blow or fall squarely upon the joint. *Indirect violence* is the ordinary cause, as from a fall upon the flexed lower limb during adduction and internal rotation, or from an object falling while the patient is in some such position as the above, or its equivalent, resulting in the usual backward dislocation through rotation of the pelvis. They almost always occur

in adults, but very recently the writer reduced a case in a 11-year-old girl.

Varieties.—Many are described, but practically they consist of: *Anterior*, the rarer form, includes *pubic*, *suprapubic*, *infraspinous*, *supraspinous*, *obturator*, and *perineal*. *Posterior*, the usual form is the *dorsal* (iliac and ischiatic included); *everted dorsal* is a rare type of this group. According to Allis all forms are either inward or outward. He thus classifies them:

Low thyroid. Midthyroid. High thyroid	All show abduction and outward rotation.
Low dorsal. Middorsal. High dorsal.	All show adduction and inward rotation.

Symptoms.—The prevalent *backward* form will be described, as more than one-half the cases are of this variety (Fig. 184). Disabil-

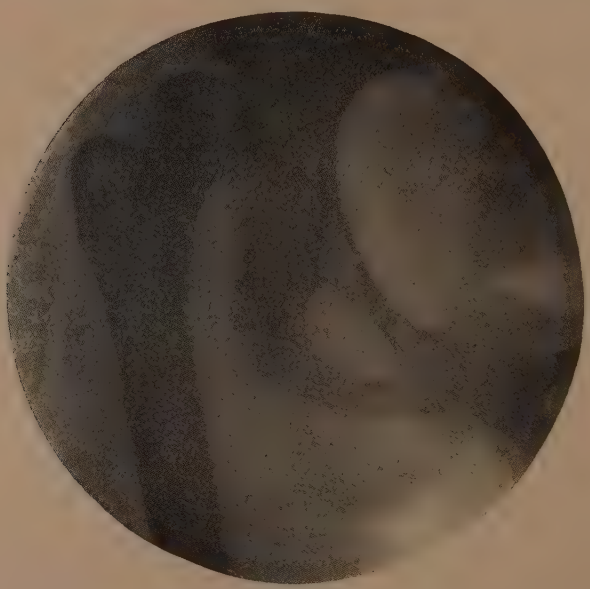


Fig. 184.—Dislocation of hip (posterior)). Treatment instituted: full anesthesia; patient placed on floor; reduction by flexion and rotation; application of long padded wooden side splint from axilla to below heel; passive motion in two weeks; active motion one week later.

ity is immediate and complete from pain and deformity, and the patient cannot stand or walk on the injured limb.

Inspection shows deformity of attitude with the limb shortened and

adducted; the knee is bent and rests on the opposite knee; the foot points downward and the sole rests on the opposite instep. Trochanter outline lessened; muscles tense; gluteal fold higher; ecchymosis or signs of contusion or external damage may also appear (Fig. 185).

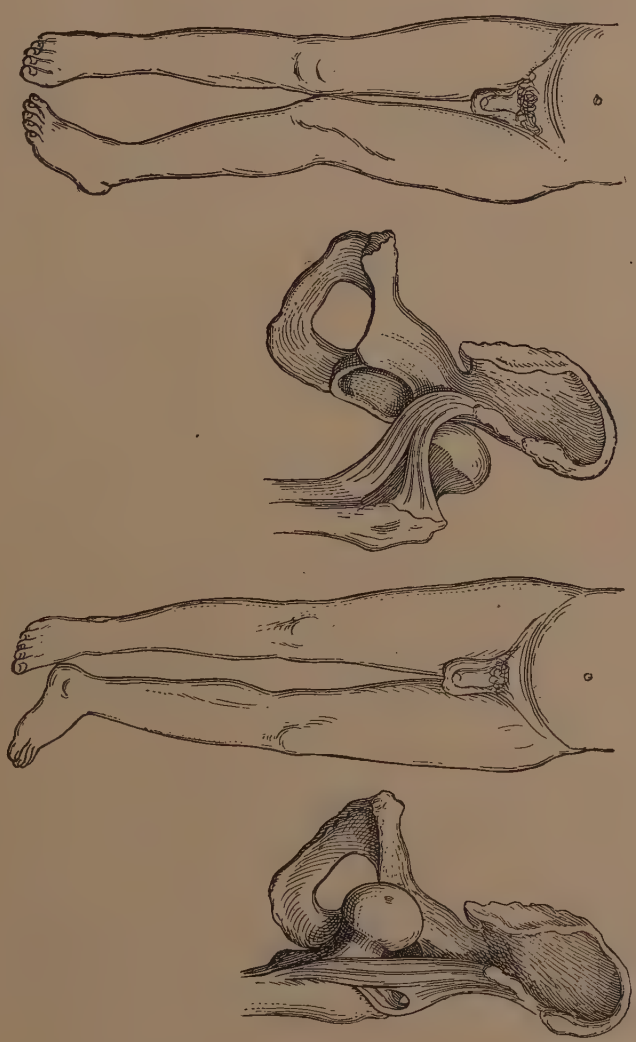


Fig. 185.—Dislocation of the hip: *a*, Posterior form, showing typical deformity; *b*, posterior form, showing position of head of bone; *c*, anterior form, showing typical deformity; *d*, anterior form, showing position of head of bone. Note that in each instance the *head* and *internal condyle* and the *great trochanter* and *external condyle* lie in the same axis respectively.

Palpation.—Pain on pressure and manipulation. Great trochanter palpable, and it rotates in an abnormal position. Motion is limited, but the deformity can be slightly increased. No crepitus or false motion exists and the entire bone can be made to rotate.

The fascia lata tends to become relaxed. The head of the bone points practically in the same direction as the internal condyle at the knee, and this is the best single indication as to the type of dislocation; the great trochanter is in the same axis as the external condyle (Fig. 186).

Measurement.—This is hard to make in the vertical direction because the limbs are not parallel, but there will be a shortening of less than an inch generally. The trochanter lies above the line from the anterior spine to the top of the ischial tuberosity (Nélaton's line).

Differential Points.—*Fractured neck of the femur* (impacted) is the most likely to be confusing; from a practical standpoint it is wise

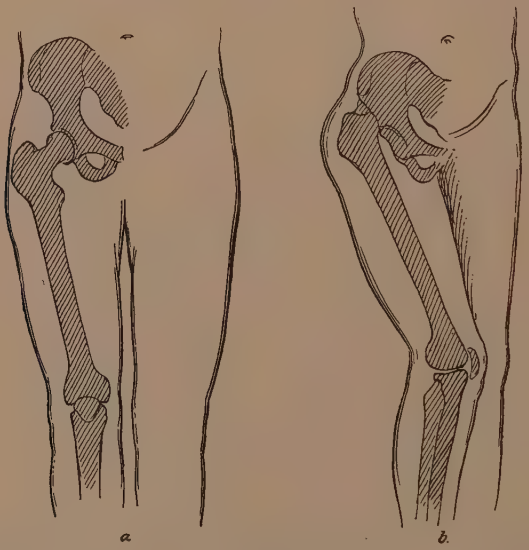


Fig. 186.—Relation of head of femur to condyles: *a*, Head and internal condyle in same vertical axis; *b*, great trochanter and external condyle in same axis.

to suspect and exclude this before diagnosing dislocation. In *fracture* the manner of accident is usually less severe; the limb is usually *everted* or straight and there is not so much flexion at the knee or muscle tension; the trochanter is not displaced, and with fracture there is visible and palpable fulness below Poupart's ligament at the upper part of Scarpa's triangle; measurements are different. Any disabling injury of the hip-joint in a person over forty-five is most likely to be a fracture of neck of femur; in this joint fracture should be the first and dislocation the last thought.

Treatment.—*Reduction* is carried out by manipulative methods only, preferably under anesthesia. The patient lies supine on a low

table or, better, on the floor, and whatever the method, it is essential to fix the pelvis firmly.

Bigelow's Method (*Circumduction*).—(1) Flex thigh on the abdomen and lift, adduct, and rotate it inward; (2) evert and rotate outward; (3) extend the limb (Fig. 187).

The foregoing manipulation is thus one of circumduction, the reduction usually occurring just before extension begins.

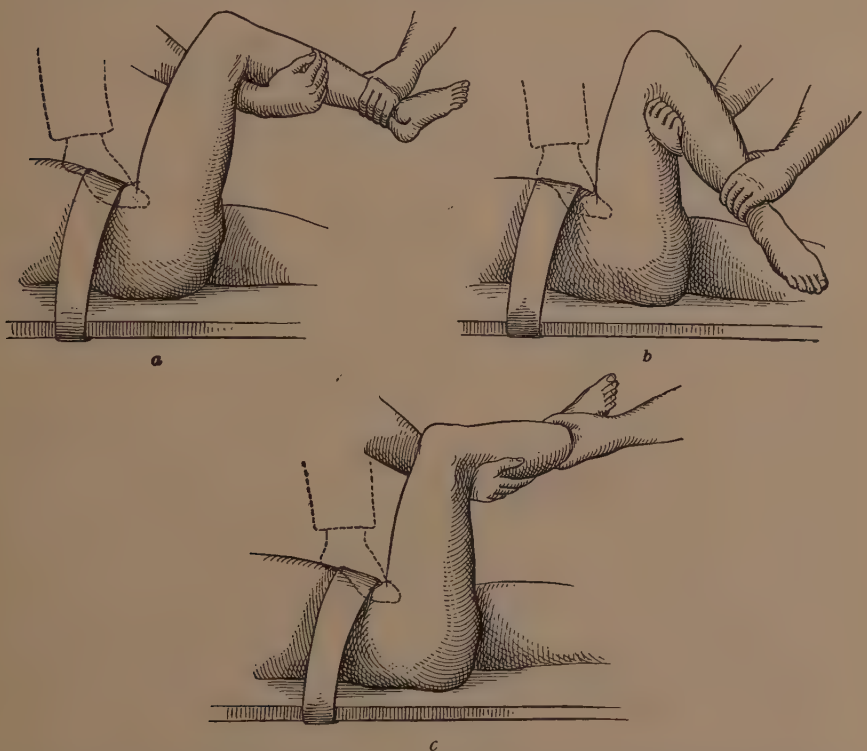


Fig. 187.—Reduction of dislocation of hip (dorsal): *a*, Thigh *flexed* and *elevated; b*, thigh *externally rotated* and *abducted; c*, thigh *internally rotated* and *adducted*. Dotted lines indicate use of the stockinged foot instead of a band to fix pelvis.

Allis' Method.—(1) Flex thigh on abdomen to or beyond a right angle; (2) lift up; this may accomplish reduction, but if not, some internal rotation is needed; (3) extension, a step that may be unnecessary if the foregoing is successful. The hand or fist in the groin may help by fulcrum action (Fig. 188).

The pelvis can be fixed by straps or other device, or a stockinged foot can be used for this purpose.

Stimson's Method.—Patient lies face downward on a table, with both

thighs dangling over the edge. An assistant holds the sound limb horizontal. First, flex knee to right angle and make steady, gradual forward pressure over the popliteal region. Second, traction-gravity produces the reduction when the muscles tire; slight rocking or rotation may assist. This is the safest and simplest method of all. With the patient in the Stimson position, a test of reduction is thus made (according to Allis): Flex the leg backward so that the heel almost hits the buttocks, and then let it drop; if then it rebounds half-way, the reduction has been effective, otherwise it is not, as the ham-strings are thus demonstrated to be acting improperly.

Anterior Dislocation.—*Outward Rotation Method.*—(1) Thigh flexed, with original deformity preserved; (2) adduction and internal rotation; (3) external rotation and extension.

Allis' Method.—(1) Abduct the sharply flexed limb; (2) pressure

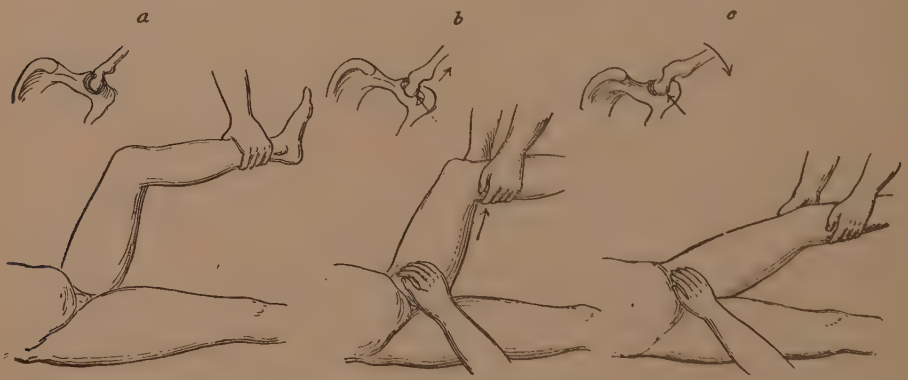


Fig. 188.—Reduction of dislocation of hip (Allis' method): *a*, Flexion; *b*, lifting up or elevation; *c*, extension and lowering.

out and back by the assistant's fists held against the head of the bone; (3) adduct the limb against resistance of the assistant's fist.

After-treatment requires that the limb be held parallel and immovable by sand-bags, a long side splint, or by tying the knees together. Two weeks of this is enough, and after that gradually increasing use is allowable. A month or six weeks should elapse before weight bearing is permitted.

Old and Unreduced Dislocations.—Open operation is generally necessary, because manipulative attempts are likely to cause fracture. As in congenital dislocation, a new acetabulum will be formed, and many of these patients get about surprisingly well considering the conditions.

Results.—Prompt reduction leads to early and complete recovery.

Recurrence is a rarity. The pain, stiffness, and weakness disappear in time, and if use is begun within two months the occurrence of limiting adhesions is largely prevented. The vast majority of cases entirely recover.

KNEE DISLOCATION

This is relatively rare and ordinarily is an associate of fracture.

Landmarks.—*Condyles*, internal and external, are readily palpable, the inner especially; *tubercle tibia*, generally palpable and occasionally visible; *patella* and *tendons* are located to determine synovial limits; *head of fibula* easily palpable and often visible; *top of tibia* especially well-marked on flexion of the joint.

Varieties.—*Forward*, the usual form; *backward*, rarer; *lateral*, quite rare, either internal or external, the latter being more common.

Causes.—*Direct violence* rarely is at fault, as by a blow or weight falling upon the joint. *Indirect violence*, as in falling, or by a twist of the knee, is the usual cause.

Symptoms.—Disability is immediate and complete from deformity and pain. *Inspection* shows a distorted, bent knee, with or without effusion into the joint, and signs of contusion or other external damage. *Palpation* demonstrates the tibia, fibula, and patella abnormally placed, but there is no bony crepitus or false motion, thus excluding fracture. Lateral motion is much increased; pain on manipulation is marked.

Recently I had at the Post-Graduate Hospital the antero-internal dislocation indicated by the annexed radiographs. The symptoms simulated a supracondyloid fracture of the femur and the patient was admitted to the hospital with that diagnosis. This unusual condition was due to a fall of about 20 feet, a mass of débris falling with and upon him. Reduction under anesthesia was easily accomplished. His recovery was practically complete.

Treatment.—Under anesthesia reduction is generally easily made by manipulation and reaction; indeed, direct traction usually succeeds, and should be tried first.

After-treatment consists in the application of a posterolateral or circular plaster-of-Paris cast reaching from the ankle to below the groin. This is worn a month; massage should begin early, with the cast split but not necessarily removed for that purpose. Some passive motion begins when the cast is removed and a leather brace or light splint should be worn for several weeks, and weight bearing and overuse of joint enjoined for some time. Massage and increasing bending

of the joint must be a main part of the treatment if stiffness and atrophy are to be prevented (Fig. 189).

Results.—Stiffness of the knee with weakness of the leg may last several months; but if early massage and restricted use form part

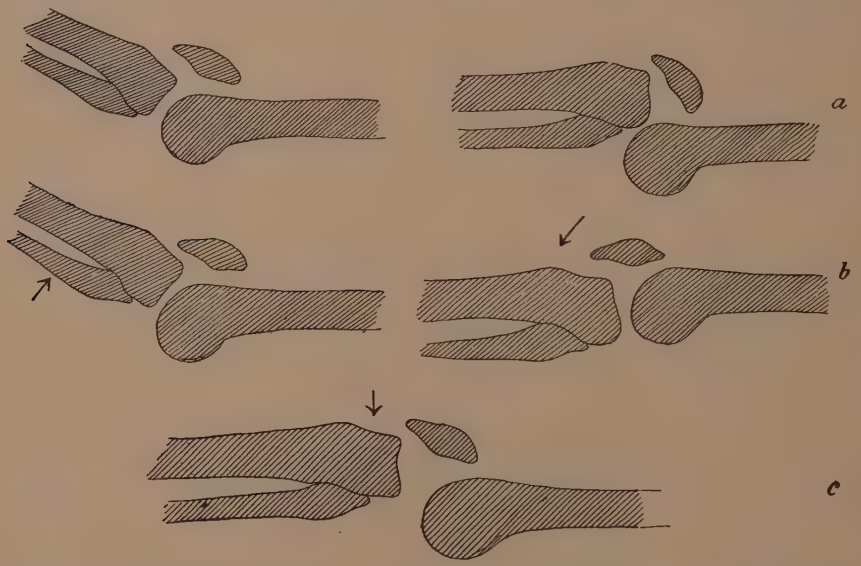


Fig. 189.—Dislocation of knee forward: *a*, Two types of displacement; *b*, *c*, arrows show direction of traction for reduction.

of the treatment a successful outcome is reasonably assured. Most cases get entirely well; some are left with limited motion at the knee and some deformity of the joint.

PATELLA DISLOCATION

This is rather rare except as a congenital affection, or as accompaniment of bow-legs, knock-knee, or fractures. It is stated that only about 200 cases of the ordinary variety are on record (Keen's *Surgery*, Vol. II, p. 426).

Varieties.—*Outward*, the usual form; *rotatory*, in which the articular surface is more or less reversed; *inward*, exceedingly rare.

Causes.—*Direct violence* rarely is productive; usually it follows *indirect violence*, as by a twist or fall, or from *muscular action* causing sudden quadriceps contraction.

Symptoms.—The patient drops immediately from deformity and pain, and disability is complete. *Inspection* shows a distorted knee; the quadriceps stands out; signs of synovitis begin promptly; the

margins of knee (especially the inner) are unduly prominent. *Palpation* shows the firm patella between rigid bands, where it ought not to be; parts of the joint generally hidden are seen or felt; some extension but no flexion is possible, but with pain; there is no crepitus or false motion as in fracture.

Treatment.—*Reduction* is generally easy by straightening the joint (extension), pressing on the knee-pan at the same time, the hip being bent to relax the quadriceps. If this is unsuccessful after a few trials, anesthesia should be used. Sometimes it is advisable to bend the knee before trying to straighten it.

After-treatment is practically that of synovitis. A posterolateral splint should be worn three weeks, some massage beginning in a week, with the splint in place. Thereafter some form of knee support should be used for several weeks.

Results.—Most cases get well completely; stiffness of the swollen knee and atrophy of the thigh are the last to disappear.

Recurrent Dislocation.—This is due to some anatomic or pathologic condition, such as abnormal formation about the condyles, bow-legs, knock-knee, and laxity of the ligaments. *Treatment* is operative.

ANKLE DISLOCATION

This very rarely occurs except as an accompaniment of fracture, notably Pott's fracture, and most reported uncomplicated cases antedated the *x*-rays.

Landmarks.—*Malleoli:* the *external* is prominently visible and palpable and reaches ½ to 1 inch below and in front of the internal; the relation here is analogous to the styloids at the wrist. The *internal* is less well marked, but can be made out; it is important to note the normal ridges and spurs on the lateral and vertical surfaces. *Astragalus*, just in front of and below the external malleolus. *Os calcis*, posterior margins sometimes visible and always palpable. *Peroneal tubercle*, just below the external malleolus, is often visible and is readily felt. *Scaphoid*, the only prominent bony mark on the inner side of the foot. *Fifth metatarsal*, base can be felt.

Varieties.—*Forward*, rare; *backward*, the common form; *lateral*, cannot occur without fracture.

Causes.—*Direct violence* from a blow or falling weight is a rare cause. *Indirect violence* from a fall or trip on the twisted foot, or by some crushing or jamming force, is the usual producing factor.

Symptoms.—Disability is generally complete from pain and deformity, and the joint will not bear weight unaided. *Inspection* shows

a distorted foot with abnormal prominences about the joint, and the submalleolar tendons are tense. *Palpation* shows the joint margins awry; there is no crepitus or false motion as in fracture; motion abolished and painful.

Treatment.—Under anesthesia, manipulation and traction the reverse of the deformity, produce *reduction*.

After-treatment requires a posterolateral plaster-of-Paris molded splint made on the style of Stimson's splint (see Pott's Fracture). This is worn three or four weeks, massage being given through it after the first few days. A rubber bandage, strapping of adhesive, or other support may be advisable for several weeks after the splint is removed.

Results.—Most cases get entirely well; there may be pain, stiffness, and weakness for some months, especially if splintage is prolonged and massage and reasonable use deferred. Working disability period is from six to ten weeks; less in occupations where standing and walking are not demanded.

FOOT DISLOCATION

These are rare and generally associates of fracture or other complication. *Astragalus* is occasionally dislocated (ordinarily compound) by the same sort of violence that produces ankle fracture or dislocation.

Symptoms are those of distortion in front of the joint where the rounded top of the bone can be felt. Subastragaloid dislocation and fracture must be excluded.

Treatment.—This often has to be operative even where repeated trials of manipulation under anesthesia have been adequately made. Indeed, operative removal is regarded often as the method of choice because, even if successfully reduced, nutrition so suffers that necrosis is very common and may lead to infection and amputation. After removal of the astragalus there is little or no lasting disability, deformity, or discomfort. *After-treatment* is the same as for ankle dislocation or fracture.

Results.—If reduced (with or without removal of the bone) function is ordinarily perfect. Working disability period six to twelve weeks; less in non-laborious occupations.

SUBASTRAGALOID DISLOCATION

This refers to the luxation under the astragalus, including the os calcis. It resembles the so-called "reversed Pott's fracture" as to

Fig. 190.—Subastragaloid (calcaneo-astragaloid) dislocation before and after reduction. Patient fell 20 feet from a window (case of M. R., Harlem Hospital).

Fig. 191.—Same case as shown in Fig. 190, after reduction.

Fig. 192.—Same case as shown in Fig. 190, after reduction and splintage.

causation, symptoms, and treatment; *x*-ray examination generally determines the exact diagnosis.

Results.—These are excellent and the disability period generally does not exceed a month.

TOE DISLOCATION

Not uncommon, especially in the last joint of the big toe.

Causes.—*Direct violence,* like a blow or falling object; rather rare. *Indirect violence* is the common cause, as in tripping, falling, twisting, or jamming accidents.

Symptoms.—Pain and some disability. Deformity may be slight and most marked in the soft parts. By massaging the effusion the displaced joint ends can be felt, and fracture excluded by lack of crepitus and false motion.

Treatment.—This is by traction and manipulation; afterward a light splint is worn for a week and a circle of adhesive another week.

Results are usually excellent.

DISLOCATION OF THE TOES

These resemble those of the fingers and occur from the same set of causes (Fig. 193). If *direct violence* is at fault, a fracture is usually associated.

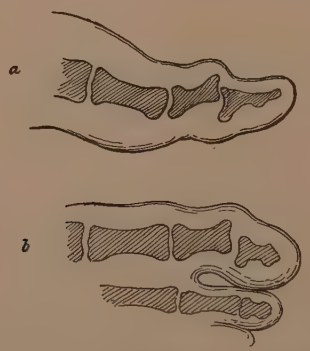


Fig. 193.—Dislocation of the distal phalanx of a toe: *a*, Posterior variety; *b*, lateral variety.

Treatment is the same as for the corresponding condition in the fingers.

CHAPTER VI

FRACTURES

A fracture means a broken bone.

Varieties.—These depend upon a number of factors relating to the bone itself and the parts contiguous to it; the following is a convenient clinical classification:

Simple or *closed fracture*, where the bone is broken, leaving the skin intact.

Compound or *open fracture*, where there is a wound in the overlying skin communicating *directly* with the bony break.

Incomplete, *bending*, or *greenstick fracture*, where the bone is not broken completely across; this generally occurs before the age of sixteen, is commonest in the forearm and clavicle, and is a rarity in adults. Undetached cracks or splinters or depressions also fall into this group.

Complete fracture, where there is absolute separation of bony fragments in varying axes, as: (*a*) *Transverse*, straight across or nearly so, commonest near the wrist and knee; (*b*) *oblique*, cleavage at an angle, the *commonest* form; (*c*) *spiral*, oblique breaks with rotation of one or both fragments, next commonest form; (*d*) *comminuted*, with splintering or fragmenting; (*e*) *impacted*, with jamming or locking of the fragments, as seen typically in the neck of the femur; (*f*) *crushing* or *compression*, with more or less pulpifying, as in the bones of the arch of the foot; (*g*) *subperiosteal*, rare, the periosteum being intact over the break; (*h*) *longitudinal*, very rare, the long axis of bone being completely split; (*i*) *T-shapted*, a combination of transverse and oblique or longitudinal, rather rare and oftenest seen at the knee and elbow; (*j*) *epiphyseal*, separation of an end from the shaft; they only occur before the twenty-first year and are practically transverse joint fractures; (*k*) *multiple*, breakage at more than one level in the same bone.

Displacement Directions.—These depend upon the site and cause of the fracture, and the separation is greatest in long bones from severe forms of violence: (*a*) *Lateral* or *transverse*, this may be to one side or forward or backward; overlapping or overriding of fragments of varying degrees is associated; (*b*) *angulation*, an exaggeration of the

above, one fragment being much displaced as a rule; (*c*) *longitudinal*, an overlapping or overriding, usually of the lower fragment upon the upper; (*d*) *rotatory*, a twisting of one or both fragments, more or less overriding generally accompanying.

Causation.—The *exciting* or *determining causes* are: (1) *Direct violence*, as from a blow squarely upon the part broken; (2) *indirect violence*, the common cause due to force transmitted from a distance, as from a fall, twist, or wrench; (3) *muscular violence*, from a strong contraction of muscles.

The *predisposing* or *secondary causes* are those depending upon some constitutional disease process. Based on the grouping of Grunert,[1] these may be—

(1) Fragility of local origin:
  (A) *Tumors.*
    (*a*) Sarcoma—primary or metastatic.
    (*b*) Carcinoma—metastatic.
    (*c*) Thyroid inadequacy.
    (*d*) Enchondroma and cysts (echinococcus of bone).
    (*e*) Hypernephromata.
  (B) *Inflammatory.*
    Osteomyelitis—pyogenic, tubercular, or syphilitic.
  (C) *Aneurysms.*
(2) Fragility of constitutional origin:
  (A) *Nervous diseases.*
    (*a*) Locomotor ataxia (tabes).
    (*b*) Syringomyelia.
    (*c*) Mental (as paresis).
  (B) Senility.
  (C) Chronic exhaustive diseases (as diabetes, nephritis).
  (D) Atrophy of non-use.
  (E) Scurvy (children).
  (F) Rickets—osteomalacia.
(3) *Idiopathic fragility*, like osteoporosis and fragilitas ossium.

Of the foregoing, the commonest are tumors, syphilis, tabes, rickets, and local bone changes.

Healing Process.—The progress toward repair is similar to that of damaged soft parts. Essential elements for osseous repair are the *periosteum* and *cortical bone*, as new bone cells are reproduced therefrom; these cells are called *osteoblasts*. When any bone is broken the (*a*) bony edges are more or less separated; (*b*) the periosteum is torn,

[1] *Deut. Zeit. Chir.*, lxxvi.

TABLE OF FREQUENCY OF FRACTURES

			Total	Per cent.
Skull			276	5·5
Malar	9	Face and neck	415	8.3
Nasal	224			
Superior maxilla	15			
Inferior maxilla	167			
Spine	22	Trunk	649	12.9
Pelvis	35			
Sternum	4			
Ribs	588			
Clavicle	296	Upper extremity	2245	44.5
Scapula	20			
Humerus	123			
Condyles	91			
Radius and ulna	101			
Radius	124			
Colles	403			
Ulna	106			
Olecranon	49			
Carpus	5			
Metacarpus	264			
Phalanges	663			
Femur	90	Lower extremity	1443	28.8
Neck	64			
Patella	61			
Tibia and fibula	314			
Tibia	97			
Internal malleolus	35			
Fibula	56			
External malleolus	37			
Pott's	393			
Tarsus	47			
Metatarsus	111			
Toes	138			
Total			5028	

The above list of representative fractures was selected from the statistics of several hospitals in New York City, and comprises ambulatory and ward cases.

			Total	Per cent.
Skull			422	17·5
Malar	8	Face and neck	142	5·9
Nasal	10			
Superior maxilla	62			
Inferior maxilla	61			
Hyoid	1			
Spine	26	Trunk	154	5·5
Pelvis	43			
Ribs	85			
Clavicle	50	Upper extremity	449	18.7
Scapula	12			
Humerus	184			
Radius and ulna	90			
Radius	38			
Colles	49			
Ulna	15			
Olecranon	6			
Metacarpus	5			
Femur	392	Lower extremity	1341	54.1
Patella	51			
Tibia and fibula	350			
Tibia	111			
Fibula	135			
External malleolus	26			
Pott's	176			
Metacarpus	4			
Metatarsus	18			
Foot	66			
Os calcis	12			
Total			2508	

The above list of fractures was taken from the records of Harlem Hospital and represents all the cases treated from 1911 to 1916, but does not include ambulatory cases.

			Total	Per cent.
Skull			1	.09
Ribs	1	Trunk	7	6.36
Sacrum	2			
Pubes	2			
Spine	2			
Clavicle	6	Upper extremity	57	51.8
Humerus	6			
Radius	5			
Ulna	3			
Colles	9			
Scaphoid	1			
Metacarpal	8			
Phalanx	19			
Femur	4	Lower extremity	50	45.4
Patella	5			
Tibia and fibula	8			
Tibia	3			
Pott's	9			
Phalanx of toe	6			
Metatarsus	12			
Cuboid	1			
Os calcis	2			
Total			115	

The above list represents a group of my own railway cases treated during the past year.

separated, or stripped up, a section of it remaining attached and forming the important so-called "periosteal bridge"; (*c*) damage to the subcutaneous tissues occurs, resulting in hemorrhage more or less localized. Repair starts promptly, and the hemorrhage is absorbed and is replaced by connective-tissue cells in the form of a plastic exudate. The periosteum and cortical bone begins to form new osteoblasts, and this and the foregoing unite to form a soft gluey mass called the *temporary* or *provisional callus*. The more perfect the bony fragments are replaced, the sooner will this mass coalesce and the smaller in amount will it obviously be. If the fragments are well coapted, we get, in effect, primary union (first intention); if not, we get union by secondary union (secondary intention), with the formation of much osseous granulation tissue or callus (Fig. 194). The central part of the bone (medulla) helps also in the process by plugging the canal of the

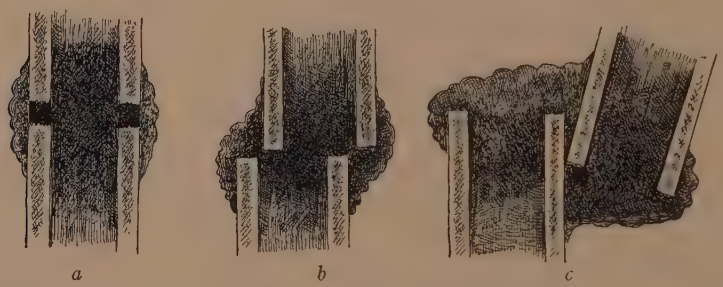


Fig. 194.—Callus formation following a fracture: *a*, Reduction complete; *b*, reduction nearly complete; *c*, reduction incomplete. In *a* there will be primary or first intention union. In *b* and *c* there will be secondary or second intention union.

bone and forming what might be termed an "intramedullary splint." This soft callus gradually hardens and begins to be replaced by actual bone in from twelve to sixteen days, the ossification being chiefly due to cells derived from the periosteum and adjacent cortex. All this time the bony fragments are ensheathed in an envelope of oval shape much like the joint made by a plumber in joining a broken lead pipe ("plumber's wiped joint"); this is the so-called "ensheathing callus." This stage of *bony* or *permanent* callus proceeds and the mass is gradually reduced in size by a process of rarefaction and condensation, and meanwhile the plug in the medulla becomes traversed by the normal lamellæ, and finally nothing remains to bridge over the break except a layer of callus on each side of the fragments under the periosteum, and this final result in repair is known as *cortical callus*.

It is thus seen that the whole process toward union is one of scar formation analogous to that occurring in the skin or other soft parts.

The average time for the formation of bony callus naturally varies in different bones, and is about as follows: three weeks, clavicle, ribs; four to six weeks, arm, forearm, leg; six to eight weeks, thigh.

In children union is somewhat more rapid; in the aged, a little slower. The better the setting, the quicker the union. Simple (closed) fractures unite somewhat sooner than clean compound (open) fractures. Infected compound (open) fractures unite more slowly, as do multiple or comminuted fractures.

Impaired Healing.—Where union is prolonged two or more weeks beyond the average, we speak of it as *delayed union*. If the union occurs with the interposition of fibrous tissue, we speak of it as *fibrous union* (also called *false callus*). This junction by a fibrous band is common in the neck of the femur, patella, and olecranon. If a joint-like junction is effected we call it *pseudarthrosis* or *false joint;* this is exceedingly rare. When there is little or no union we speak of it as *non-union*. Strictly speaking, it is rare for this to occur, as in time *some sort* of union always ensues. When there is much deformity or disability after union, we speak of it as "faulty" or "vicious union"; this is commonest in the clavicle, arm, forearm, leg, and thigh.

Causes of Impaired Union.—These may be: (1) *Local*, due to the bone; (2) *general* or *systemic*, due to constitutional disease.

(1) *Local.*—(*a*) *Imperfect setting* and *immobilization*, resulting in separation of fragments. This is *the main cause*. (*b*) *Intervention between fragments*, of bone, muscle, tendon, or other soft parts. (*c*) *Infection* by pus-producing germs. (*d*) *Deficient blood-supply* from original blood-vessel damage or subsequent treatment. (*e*) *Tumors of the bone*, like sarcoma.

(2) *General.*—Acute infectious diseases, tuberculosis, syphilis, rheumatism and gout, nephritis, diabetes, alcoholism, rickets, anemic states, locomotor ataxia, syringomyelia, paralysis, and paresis. I firmly believe that distant and perhaps relatively quiescent pus foci are foes of early union and are often the source of infecting blebs; oral and genito-urinary septic foci are the commonest sources.

Practically speaking, the main cause is improper setting and imperfect splintage; the next commonest cause is interposition of soft or hard parts. I do not believe syphilis to be a marked factor; if it was, non-union would be exceedingly common.

Fracture Symptoms.—These are: (1) *Subjective*, related by the patient; (2) *objective*, apparent to the examiner.

(1) *Subjective.*—The patient makes statements as to (*a*) *pain*, usually considerable at the time of the injury; it may diminish for a

short period soon thereafter and recur when the "secondary swelling" begins. After setting, it may completely cease, but always diminishes. It may be located at the site of the break or radiate therefrom. Alcoholics and syphilitics feel it but little, and it is less marked when there is wide separation of the fragments or when they are impacted. Generally it is more severe near a joint or about parts rich in nerve supply. Expressions of pain vary largely with the individual and the circumstances of the accident. Workmen, soldiers, athletes, and others occasionally pay little heed to pain under the excitement or interest of work or contest.

(*b*) *Disability.*—Usually loss of function is more or less complete from pain or deformity, or both; this greatly depends upon the site and nature of the fracture and the manner of its receipt. The disability becomes more manifest upon purposeful efforts to functionate, and it is greatest in those bones necessary to the work or object in hand.

(*c*) *Audible Sensations.*—Frequently a patient will say "I heard something crack"; in reality, any such sensation must be more imaginary than real.

(*d*) *Deformity.*—Usually spoken of in terms of distortion or swelling; this varies within wide limits.

(2) *Objective.*—These are the most essential, and should be searched for systematically. The pathognomonic signs of respective fractures will be stated in detail later.

(*a*) *Inspection.—Deformity.*—Indicated by the *attitude* of the patient and the outline or axis of the part affected.

Swelling.—This may not appear for an hour, and is greatest in vascular areas and where the bone is close to the surface or main joints.

Discoloration.—Redness may appear within a few moments, to be followed by more or less diffuse bluish discoloration within a few hours. Localized and late, it is very suggestive of fracture; as, for instance, the postmastoid ecchymosis of fractured base of skull, or of the perineum in fracture of the pelvis. It may be very extensive and extravasate a long distance, as in a fractured arm with ecchymosis reaching to the elbow and midchest.

Blebs (serous or bloody) are typical of fracture and may occur after the first few hours. They are most marked in simple fractures of the leg, but are rare in all forms of compound fracture because the wound of the latter appears to relieve subcutaneous tension by a sort of spontaneous decompression.

(*b*) *Palpation.—Deformity* sometimes can be outlined. *Pain*

elicited by direct or transmitted pressure or motion of the part. Even in the absence of other signs, the presence of *localized* or *point pain* is very suggestive; this is notably so in the clavicle, forearm, and fibula.

(*c*) *False motion* occurs in fractures and in no other condition, and is the only *pathognomonic sign* of such lesion. It must be elicited carefully; it is least reliable in the presence of much effusion or near joints, and most valuable in fracture of the shaft of long bones.

(*d*) *Crèpitus* is the most unreliable sign, as it is inconstant, occurs in other conditions, and to elicit it often causes needless pain and damage.

(*e*) *Tension* or *spasm* is often noted in adjacent muscles, especially in upper thigh fractures.

(*f*) *Motion*, passive and active, is limited by pain, spasm of muscle, and deformity. Certain abnormal motions may be increased, as in Pott's fracture.

(*g*) *Auscultation.*—Combined with percussion, a change in the note is apparent by use of the stethoscope or ear; most marked in the skull, clavicle, and ribs, when little or no separation has occurred.

(*h*) *Measurement.*—Ordinarily *shorter* in the vertical and *larger* in the transverse diameter.

(*i*) *X-ray.*—Usually not needed. Fluoroscopic examination is exceedingly unreliable and deceptive. Radiographs should be made in two axes of the limb, and the uninjured side should be shown on the same plate if possible, and all the plates should be made with the same focus and the same axis, so that false shadows will not be possible.

Complications.—Those relating to the bone have been referred to under Impaired Healing; the others may depend upon (1) *local* or (2) *general* or *systemic causes*.

(1) *Local Causes.*—*Skin* may be contused or otherwise damaged by the initiating violence, or later from the swelling; either occasionally leads to ulceration or gangrene. A bleb allowed to become infected or pressure from a splint may act likewise.

Blood-vessels may be excessively torn, leading to hemorrhage; inflammation of vessels may cause *arteritis* or *phlebitis*. *Embolism* or *thrombosis* occasionally occurs, most commonly of a pulmonary type in the aged. *Aneurysm* is a very rare sequence.

Nerves may be *contused*, *lacerated*, or *severed*. Some *trophic* changes and disturbances of *sensation* may also occur, causing anesthesia or hyperesthesia. *Neuromata* rarely occur.

(2) *General Causes.*—*Shock* of some degree is an incident of most fractures; it rarely lasts more than a short time, and if profound,

generally indicates severe or associated injury, and frequently is a symptom of hemorrhage.

Fat embolism is generally a late manifestation. Fat gets into the circulation in every fracture, and is generally found in the urine. If emboli result, the lungs, brain, and kidneys are oftenest affected; sometimes areas of infarction form that may lead to death.

Sepsis is limited practically to compound (open) fractures. The pus-producing organisms, especially staphylococci, are the common offenders. The germs of tetanus, malignant edema, and the Bacillus aërogenes also occasionally gain entrance.

Delirium tremens is rather common and occurs usually in steady drinkers who may be practically sober when hurt, and to them the

Fig. 195.—Coat-sleeve sling.

Fig. 196.—Coat-sleeve sling.

shock of the accident, the enforced idleness, and the withdrawal of alcoholic stimulation is too much for a nervous organism that has been more or less nourished by alcohol. This is a very serious complication, and it is a good rule to administer prophylactic doses of bromids and chloral (or other sedatives) at once to any patient of known alcoholic type, or to one who shows tremor of the tongue, fingers, or muscles, especially if insomnia coexists.

Traumatic delirium is rare and is said to occur chiefly in the young and aged, or in those who are total abstainers. The symptoms are like alcoholic delirium. The writer has never seen an authentic case.

Pneumonia is rather common, especially in the aged, debilitated,

and alcoholic. If it occurs early, frank *lobar* or *lobular pneumonia* generally exists; later, *hypostatic pneumonia* is more usual, and then the pulmonary symptoms are not marked, but the condition is usually one of great prostration, dry tongue, somnolence or irritability, and low delirium, with terminal edema and coma.

Treatment.—This may be divided into: (*a*) Primary or first aid; (*b*) reduction or setting; (*c*) immobilizing or splinting; (*d*) restoring function by massage, manipulation, or apparatus.

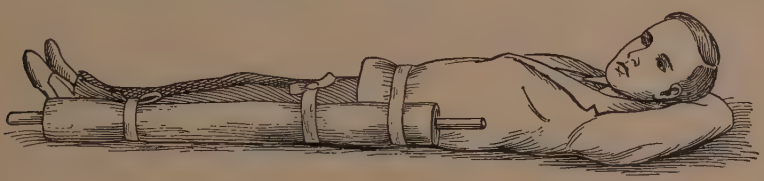


Fig. 197.—Improvised splint made from a coat or blanket rolled on a pole or rail.

(*a*) *Primary* or *first aid* has to do with the transportation and initial care up to the time of setting. Every effort should be made to keep the part in as nearly a normal position as possible, and free of all encircling pressure. If a patient is to be carried, one person should be given sole charge of the injured part and others should perform the actual lifting. A coat, two shirts, or a blanket rolled upon canes, slats, or broomsticks (Figs. 195–198) makes an efficient splint that will

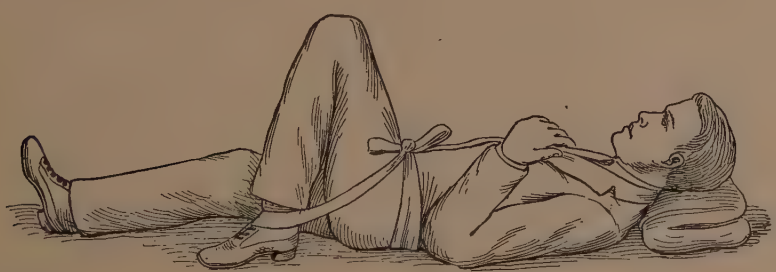


Fig. 198.—Hyperflexion of the knee, acting as an improvised tourniquet for bleeding from a fracture below the knee.

prevent compounding a simple fracture. A shutter or cellar door makes an excellent litter. A bleeding compound (open) fracture may need a tourniquet occasionally; the wound is better left exposed unless it can be covered by sterile material. With the patient in bed, the part can be kept motionless by sand-bags or padded bricks, or by some improvised loose splint made from a pillow, a pasteboard or wooden box, shingles, or fence-slat.

(*b*) *Reduction* or *setting* is the *most important* element and the key to the outcome, as no splint or other device can promise a good result if the setting is inadequate or faulty; conversely, the splint is relatively unimportant if good setting has been accomplished. The bone should be set *as soon as possible.* However, it is to be appreciated that there are two general classes of fractures, namely: (1) **displaced** and (2) **non-displaced.** The former demand *reduction* and *retention* as essentials of treatment; but the latter require *retention* only. In other words, some fractures must be set and splinted, but others need only splintage.

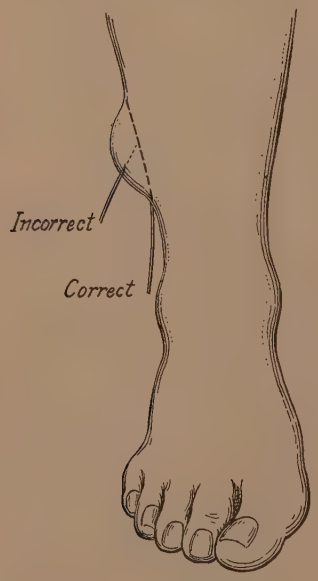


Fig. 199.—Opening a bleb. The *correct* method is to transfix, incise, or aspirate at the junction between the sound and unsound skin. The *incorrect* method is to make the opening at or near the summit.

Anesthesia is a valuable aid, notably in fractures about the wrist and ankle. Nitrous oxid, ether, or ethyl chlorid should be used in preference to chloroform, because the latter seems dangerous in this as in most injuries. Primary anesthesia only is needed, as a rule, but care must be observed in keeping the dressings intact when the patient is regaining his senses.

Traction, pressure, and manipulation are the maneuvers used, and where anesthesia is declined or inadvisable, some relief from muscular contraction can be obtained if the limb is allowed to dangle; or if pressure is made for a few minutes over the main blood-vessel (as the axillary or femoral); or if the limb is placed in salt and ice until the "freezing" effect is gained.

Blebs are opened only if they are likely to interfere with the dressings; the later they are opened, the less the chances of infection. They should be iodin sterilized and transfixed at their base with a sterile instrument (Fig. 199).

(*c*) *Immobilizing* or *splinting* may be temporary or permanent. The essentials of a splint are: (*a*) Safety and adequacy; (2) ease of application and removal; (3) comfort, light weight, pressure freedom; (4) ready inspection of the part; (5) cheapness; (6) capability of being used from start to finish.

The usual splint is of basswood or white wood or plaster of Paris.

Felt, tin, aluminum, and other materials are also used. The "sets of splints to fit any fracture" are usually about as valuable as the average machined horseshoe before it has been shaped in the forge; it is wisest to make the splint fit the fracture rather than the fracture fit the splint.

Strips of freshly prepared plaster of Paris, so shaped or molded as to fit the part, make excellent splints for the arm, forearm, lower thigh, and leg fractures; these so-called "molded plaster-of-Paris splints" meet all the essentials named above and they can be applied at once.

If swelling of the part is excessive, the limb should be shaved and protected by layers of loosely applied gauze or cotton, and then placed in an elevated *temporary splint* made of a gutter-shaped box or tin trough which extends far enough up and down to fix adjacent joints. If a molded plaster-of-Paris splint is used, it is not necessary to await the decrease of the swelling. Splints of wood $\frac{1}{8}$ to $\frac{1}{4}$ inch thick suitably padded can be placed laterally on a limb as a temporary support; they should always be wider than the limb and well protected to prevent pressure. In from one to ten days swelling should diminish enough to allow a permanent dressing to be applied, and this is generally of plaster of Paris, either a *circular plaster* or *molded plaster* cast.

Circular plaster casts are applied by first shaving the limb and then washing it with soapy water and later with alcohol. After being dried, it should be powdered with talcum or borax. Blebs are painted with iodin and punctured and covered with sterile gauze. A flannel or sheet lint bandage is then applied, snugly, smoothly, and circularly; any reversing will cause pressure and wrinkling. In lieu of flannel or lint, sheet wadding, stockinette, or several thicknesses of gauze or cotton may be used. The plaster-of-Paris bandage meanwhile has been soaking in hot water and is now applied, beginning at the distal end of the limb, Depending on the fracture and the bandage, from six to twelve layers of bandage will be needed. They are best made from crinoline or wide meshed gauze with "dental plaster." Any width less than 4 inches is hard to apply. Loose plaster can be rubbed on to fill in the gaps and smooth rough spots. Reinforcement can be made by strips of basswood, aluminum, wire, or tin. The limb must be carefully held while the plaster is drying, and if any swelling occurs, the cast must be *immediately split*, as pressure of a few hours may lead to irreparable damage. The cast is best cut by an ordinary heavy jack-knife; vinegar or peroxid and hot water softens plaster. If a circular cast is applied with the object of being immediately slit, this

can be best accomplished by burying a Gigli saw just under the first turn of plaster; such a dressing is called a "split circular cast." With care and some reshaping it can be used from start to finish in many cases, and the edges of it may be well protected by adhesive plaster.

Molded plaster casts are fashioned by two methods. In one (as in the shoulder or leg) a pattern is cut of the part to be enclosed, and this is then covered by many overlappings (six to twelve) from a moist plaster bandage, and while moist it is applied and held in place by gauze bandages until drying is complete, and it is then suitably held by adhesive or other means (Fig. 200). The usual method (especially in Pott's and Colles' fracture) is to determine the length and width needed, and then a piece of flannel, sheet wadding, or lint is selected an inch wider and longer than required. On this as a base a moist plaster-of-Paris bandage is unrolled until from five to fifteen thicknesses are laid, and this makes one-half of the splint, and it is then put aside until the

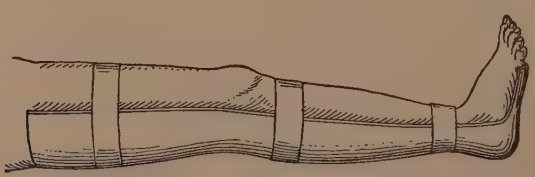


Fig. 200.—Posterior molded plaster-of-Paris, metal, or felt splint for the lower extremity; this is commonly called a "slipper" or "trough" splint.

other half is similarly fashioned. These are then applied (the flannel or wadding next the skin) and molded to fit the part and kept in place until dry by a few turns of a gauze bandage. When dry, this bandage is removed and the splint is trimmed as needed, and then fixed by a few spiral bands of adhesive, and still further reinforced by a gauze bandage. There is always a gap at the margin of such splints sufficient to permit circulation and inspection; likewise cutting one edge of the adhesive allows either portion of the splint to hinge over like the lid of a box, and thus give access enough for greater inspection, massage, or motion when desired.

Other Casts.—Flour paste and paper make a fairly firm and light molded splint. "Yucca wood" and felt are useful in some cases. Sheet aluminum, tin, and wire netting also are used.

Window Casts.—In a compound (open) fracture it is often necessary to have a gap in a circular cast for dressings, and such a hole is called a "window." It is best to cut this while the cast is hardening,

the required area having been previously determined. If an inverted tin cup or small wooden block is placed over the site of the "window" after one layer of plaster is applied, the lump thus formed acts as a guide for the cutting out of the plaster after it hardens. The margins of such a window can be protected from raveling and soiling by a lining of gutta-percha tissue, oil silk, or adhesive. The former is purchasable in yard-square sheets and is about as thick as paper. Mixed with chloroform it forms a rubber glue that can be brushed on the edges of the window if desired. If the conditions require, the cast may be applied in two circular segments, the intervening part being bridged over by rods of curved iron or other metal (Fig. 201).

(*d*) *Restoring Function.*—This step in treatment occurs generally of its own accord if the preceding essentials have been successful. *No rigid splint should be used after firm union occurs. Gentle massage* can be given after the first day in practically all fractures, those at the

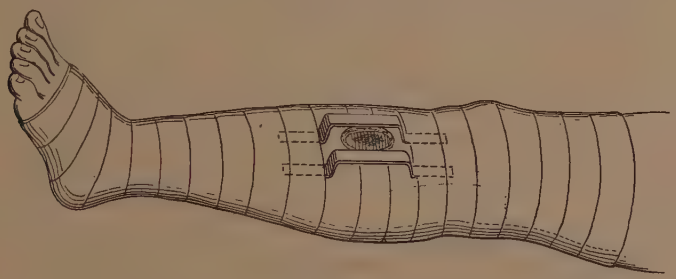


Fig. 201.—Plaster-of-Paris cast for compound fracture of leg with window and angle-iron bridge.

elbow being one exception. Each massage period is gradually increased from once daily for five minutes to twice daily for twenty minutes or oftener. Camphorated, olive oil, or cocoa-butter are good emollients. If a molded splint is used, the massage is given at first with one-half the cast *in situ*. If massaging causes undue pain, swelling, or redness, it is being given too vigorously, doing harm, and should be modified; ordinarily it causes a sense of warmth, tingling, and satisfaction. The parts above and below the actual fracture should be first massaged, gradually getting nearer to the broken area. Adjacent joints should get the most vigorous attention. The whole object is to (1) reduce swelling, (2) promote circulation, and (3) restore muscle tone during the period of enforced inactivity.

Passive motion can be given in some cases in two weeks, and in nearly all in four or five weeks. The range of motion is at first very slight and at a distance from the break, and ordinarily is given at the

end of a massage séance. The increase of motion keeps pace with the massage increase; and when it has proceeded a week or two with-

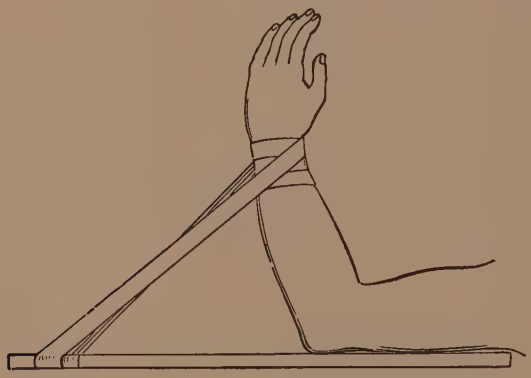


Fig. 202.

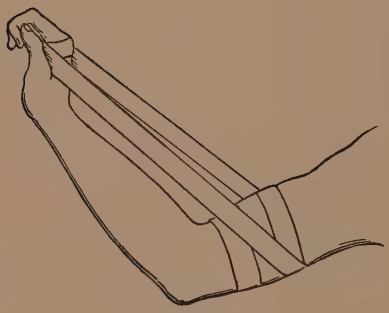


Fig. 203.

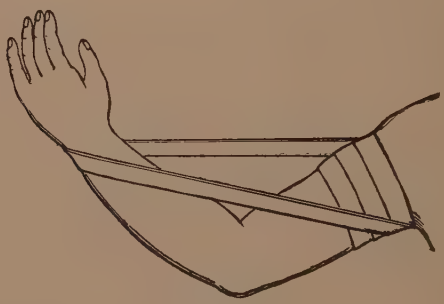


Fig. 204.

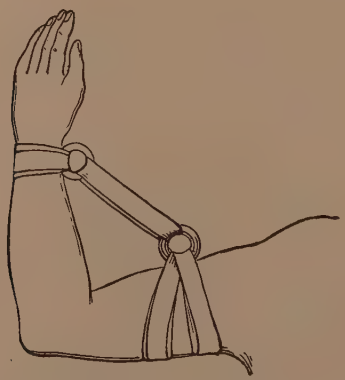


Fig. 205.

Figs. 202–205.—Rubber band exerciser for a stiff wrist or elbow. This arrangement or modification promotes flexion or extension.

out undue reaction, then the patient can be allowed to make *active motion* unaided and within narrow limits. In all cases the patient

must be cautioned to move the unsplinted parts rather vigorously; This is especially necessary in fractures of the forearm, where the fingers must be kept moving to forestall tenosynovitis. The vigorous use, in or out of bed, of dumb-bells, weight pulls, and forced breathing

Fig. 206.—Rubber band exerciser for a stiff ankle. This arrangement or modification promotes flexion or extension.

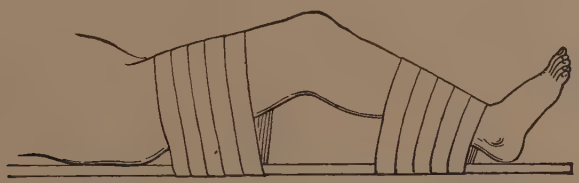


Fig. 207.—Rubber band exerciser for a stiff knee.

Fig. 208.—Rubber band exerciser for a stiff knee.

do much to prevent hypostatic complications, especially in the aged or debilitated. The methods suggested in Figs. 202–208 are self-explanatory and are of service in those cases associated with joint stiffness. The further treatment is given under Complications.

Compound or Open Fractures

Special attention is given these to prevent sepsis, leading to delayed healing, necrosis, amputation, or even death. We are dealing with a presumably infected lacerated wound *and* a broken bone in every instance, and to that degree we begin with an infection.

Primary Treatment.—The first essential is *disinfection;* the second, *conservation.* Pour tincture of iodin freely into and about the wound and then cover it with a clean dressing, but do not touch the parts. Give tetanus antitoxin, especially if there has been any chance of infection from soil or street dirt. If the part is dirty or much lacerated, or if the fracture seems severe, insist on ether or nitrous oxid being used; then shave the adjacent parts, *keeping the wound itself covered by a sterile pad* until the last. Get rid of grease with gasolene, benzin, kerosene or oil, but do not scrub or roughly handle the parts. Sop with alcohol and dry, and then paint with one-half strength ($3\frac{1}{2}$ per cent.) tincture of iodin, filling the wound to overflowing with it. The wound and the parts about it are now a relatively sterile field, and surface infection will be cared for by the iodin.

Skin at the edges of the wound if badly crushed (already dark blue or brown) had better be clipped off; do not cut skin stripped up unless it is in very thin, dark, frayed ribbons. It is generally wisest for inspection to extend the original wound by a scissors-cut unless there is a mere puncture; comminution and skin stripping make this incision imperative for the purpose of introducing iodin. Do not sacrifice any red, bleeding, or attached bony or soft parts.

Muscle or *tendon* pulpified or frayed so that it is brown or black and soft can be cut away; otherwise it is safest left alone.

Blood-vessels torn and bleeding are tied with plain or iodinized catgut.

Nerves, if important and recognizable, are anastomosed.

Periosteum is saved to the last degree, even though it is apparently hopelessly crushed; it is valuable enough to be kept.

Bone fragments, if attached, are kept, especially if only a small portion of periosteum adheres. Loose, detached, and denuded fragments are better out than in, unless they can be refitted; this is especially true of the medullary part of long bones. All soft parts preventing bony coaptation must be lifted or cut away in an effort to make reduction as perfect as possible; however, continued traction obviates much of this. Metallic aids to maintain the corrected position (wire, plates, or pins) do not act well when applied at an early stage; hence kangaroo or chromic gut should be employed for this object if needed.

Closure should begin by bringing *periosteum* over the line of break so far as possible; interrupted plain or iodized catgut sutures are used for this, without undue tension. Loosely suture *muscles* and *tendons* after the same manner. *Drain* down to the fracture site with gutta-percha (rubber) tissue, a cigarette drain, or rubber tubing; make an opening at the opposite side or lower down for counterdrainage if needed. Two small drains are four times as good as one big drain.

Skin is loosely stitched with silk, horsehair, or silkworm-gut, this stitch being interrupted and including the subcutaneous fascia. Squeeze the wound dry and cover it by eight or more thicknesses of gauze moist from immersion in iodin water ($\bar{3}$j : Oj). Do not encircle the limb until several more layers of dry gauze are applied, and then use a gauze bandage to cover all. Place the part in a box or gutter or other loose, well-padded temporary splint. See that reduction is well maintained and that the part is elevated when the patient is returned to bed. If there is much separation, bruising, or crushing of the part, it is a safer plan to do little if any suturing; in such a case the wound, after iodin cleansing, is loosely packed with moist iodin water gauze.

No wound of compounding is too small to drain; none too large to leave unsutured. Treat the constitutional signs in the ordinary manner if necessary.

After-treatment.—In the absence of much local pain, soaking of the dressings, temperature over 101° F., or pulse over 100, it is unnecessary to change the dressings until the third or fourth day; the seventh day may be early enough in some instances. At this first redressing the splint preferably remains *in situ*. If there is not much discharge, if the wound looks healthy and if signs of inflammation are lacking, then it is prudent to remove one drain completely if two were inserted. If only one was used, it can be shortened an inch and twisted in the wound to prevent adhesions fastening to it. A dry sterile gauze dressing is then applied. If, however, signs of trouble are manifested by pain, fever, high pulse, and local evidences of beginning infection, then all the stitches must be removed, the wound irrigated with hot iodin water (ʒj : Oj), and the gaping opening loosely packed with moist iodin water gauze. Support such a patient well with food, whisky (especially if a drinker), strychnin, and quinin. Regard this patient as a *septic case*. Dress the part again that same day if necessary. If there is any foul-smelling discharge (generally it is brownish yellow), then irrigate with a deep pink-colored solution of permanganate of potash and use a wet dressing of the same. Do not

use peroxid in any deep or hidden cavity. Cut away *sparingly* any black or deeply discolored, sloughing, soft, or gangrenous areas, as many of these later delimit themselves. A thickish yellow or whitish pus means usually a staphylococcus infection a great deal less virulent than a streptococcus infection, with but little or no thin pus. Green pus is usually a pyocyaneus infection of low grade. Foul, odorous discharge is probably colon infection. If there is any crepitation, bubbling, or gaseous formation in the wound the condition is dangerous, as the infection is then of the type of malignant edema or Bacillus aërogenes capsulatus. Multiple incisions and counterdrainage is then needed, with flooding of the part in peroxid of hydrogen and a plentiful gauze dressing wet in the same material, or any other oxygen carrier, such as permanganate of potash. If the local or general conditions still seem uncontrolled, then an anesthetic should be given, the splint removed, and the wound laid widely open and redisinfected by iodin. If there are pockets or sinuses, each must be drained and counterdrainage liberally provided where needed, as the condition now is a deep-seated cellulitis with perhaps osteomyelitis. The splint is reapplied with the wide open wound loosely packed with gauze soaked in iodin (1 dram to a pint of water) or permanganate (deep pink color). If at this or subsequent dressings the bone edges are wholly denuded, smooth, or sloughing, they may be sawed off (resection procedure). If this reveals an extensively invaded medulla, then the osteomyelitis will probably go on to amputation and possibly death. If, at the same time, the general state is showing deterioration, amputation should be done before it is too late. When possible, be conservative in seeking to preserve the adjacent joint, but select healthy tissue, lest reinfection occur in a new focus. When, however, the discharge is more rebellious than serious, the pouring into the wound of pure balsam of Peru sometimes acts well, and daily exposure to air and sunlight is of the greatest value. The use of bismuth paste is sometimes effective. Many of these wounds keep discharging until a sequestrum is absorbed or cast off. When the infection is under control some sort of permanent cast may be applied, usually a "circular window" or "molded" plaster of Paris is used.

General Treatment.—This is most important, and every attention must be given to the diet and general nutrition of the patient. Whenever possible abundance of fresh air and sunshine should be provided, and the septic cases especially will do better if kept out-of-doors the entire day and even at night under protected conditions. As stated, when the wound can be exposed to the air and sunlight, healing will

be greatly hastened and discharge much diminished. *Alcoholics* are provided with a reasonable amount of stimulants, and bromids and chloral are given until tremor, restlessness, or insomnia are controlled. *Aged* patients are frequently turned in an effort to prevent hypostatic complications, and the head of the bed is elevated or a back-rest is provided to aid in this. *Tonics*, like strychnin and quinin, are ordered when needed. I have never known sera to be of any great value.

Bullet Fractures

Speaking generally, the same primary treatment should be given as for compound fracture. The bullet should not be searched for unless it gives trouble, and it should first be located with reasonable certainty; *enthusiastic and early probing is often more dangerous than the missile.* Most of these cases get along best by being tampered with as little as possible, because most bullet wounds are fairly aseptic, and interference widens the bullet track and is liable to open up channels for reinfection.

Clinically, there are two general clases of cases corresponding very closely to other forms of compound fracture; namely, those with *minor* and *major* degrees of damage to the soft and bony parts.

Minor cases are those in which there is a punctured wound of entrance or exit (or both) with little or no bony comminution.

Major cases show more extensive tearing of the soft parts with bony comminution enough to deserve the term "splintering."

The bullet wound ordinarily met with is inflicted by a revolver of .32, .38, or .44 caliber. Less often a rifle or shot-gun is at fault. Obviously the bony effect is dependent upon (1) site of the wound; (2) size of bullet; (3) distance between weapon and target.

Treatment.—The primary attention is alike in both classes, and the initial effort is to sterilize the wound in an attempt to prevent greater infection. Antitetanic serum should be given at once in every instance.

Minor Cases.—First pour in or inject iodin and then cover the wound with a small piece of gauze and paint iodin about the margins for several inches; this gives a relatively sterile field to work in. If the edges of the wound are already black or gangrenous, clip them, and then press the wound apart and make the iodin again penetrate every recess of it. Remove any *wholly* detached bony fragments and then reduce the fracture with as little manipulation as possible. If there is merely a hole or tunnel through the bone, do not curet or otherwise disturb this channel.

Drain by a twisted or folded piece of rubber tissue or tubing to the bottom of the cavity; do not make this a plug or dam by ramming it in too hard. Use no sutures unless gaping or bleeding demands. Cover with a moist iodin water (℥j : Oj) or 50 per cent. alcohol gauze dressing and cotton and a bandage, and then apply a *temporary splint.* Unless needed, do not disturb this dressing for twenty-four to forty-eight hours, then apply a dry sterile gauze dressing, shortening the drain unless there is great secretion. Dress again in two to four days, and if the wound is granulating, pour in pure balsam of Peru solution, insert a few strands of catgut for provisional drainage, and apply a *permanent cast* of molded or circular plaster of Paris, with a "window" in the latter. If infection proceeds despite the above, the treatment is as indicated in infected compound fractures. The bullet meanwhile has been definitely located and removed if accessible; if embedded in bone and doing no harm, it may be left undisturbed.

Major Cases.—The preliminary sterilization is carried on in the same manner as in the preceding. Widely separated deep and superficial parts should be *loosely* stitched, if at all. Plentiful drainage by rubber or gauze in rubber is afforded, multiple openings being provided where needed. The fracture is adjusted and retained in a temporary splint. Redressing is done every day until infection disappears or is minimized, and then a *removable permanent cast* is applied; ordinarily this cannot safely be done within ten days or a fortnight. If infection gains, the treatment shifts to wider incision and drainage and the other means advocated in advancing infection of compound fractures.

In cases of greater severity, immediate amputation may be wisest; this is especially true in the event of great transverse comminution with damage to main blood-vessels, as the femoral or axillary, or where the soft parts are extensively involved; but no limb should be sacrificed unless the vascular supply is extensively damaged.

Articular Fractures

A compound fracture entering a joint is a serious matter, not only as to ultimate function, but also as to life.

Treatment.—This depends upon the extent of the original damage, and, in general, is like that early given for bullet fracture. If, after twenty-four hours, there is obvious increasing joint effusion, or if originally the joint has been invaded, then *drainage of the joint* must be plentifully provided at once (see p. 106 for Incision Sites). The joint may be flushed through and through with salt solution at first;

later, if needed, with hot bichlorid (1: 10,000), iodin (1 dram to a pint), or permanganate (1 : 200). The joint must be kept in extension.

Early amputation or *excision* is advisable if the infection progresses rapidly or where the process causes practically a disarticulation and irreparable primary damage, assuming that wide incisions and free exposure of the joint are unavailing.

Fracture Results in General

These obviously depend upon three factors: (1) Patient; (2) bone; (3) treatment.

(1) **Patient.**—*Age.*—The younger the better; after fifty years of age repair and reconstruction are slower.

Sex plays little part.

Habits and Disease.—Alcoholics act badly. Those suffering from constitutional troubles (syphilis, nephritis, diabetes, etc.) are not likely to do as well as the healthy.

Occupation.—Where active use of the part is daily needed the disability will be longer and more pronounced; a fracture about the right wrist, for example, might totally disable a typist six weeks, and yet permit a laborer to perform at least partial work in a few hours.

(2) **Bone.**—Compound or infected forms do not knit as quickly as others. Articular forms are more likely to take longer or result in greater disability. Shortening due to impaction or overriding is quite likely to some extent in fracture of the shafts of bone. This may be considerable, however, without impairing function or causing marked deformity; it is a regular incident in a fractured shaft or neck of the femur, and as much as 2 or 3 inches can be sometimes compensated for by a tilt of the pelvis and spine without noticeable limp. Flat bones (like the scapular and clavicle) quite regularly throw out large amounts of callus that, however, later diminishes.

(3) **Treatment.**—The earlier and more accurate the reduction, the quicker and more dependable the outcome. Early massage and passive motion promote healing and diminish postsplintage stiffness. Cooperation from the patient is a large factor. Splints allowed to remain undisturbed over three or four weeks (femur excepted) are almost certain to cause stiffness and atrophy inversely proportional to the length of their application; in many such instances the *treatment is often worse than the injury.* This is especially true in the aged and in fractures about joints. I have recently seen an impacted Colles' fracture in an old washerwoman, in whom splints reaching from below the elbow to

the finger-tips were allowed to remain undisturbed nine weeks, and the resulting stiffness will be largely permanent.

Baking, electricity, and apparatus designed to make forced gradual motion (like "Zander" machines or the "arthromotor") are of great value for the relief of adhesive stiffness or atrophy. Operation to correct unreduced deformity or arthroplastic procedures are final steps in regaining function.

The vast majority of cases are restored to full working capacity even in the presence of obvious great deformity. In respect to the latter, *x*-ray examination may disclose marked distortion and displacement even though the functional outcome is excellent; hence it is important for the physician and the patient to realize emphatically that *deformity does not necessarily mean disability.*

Before predicting permanency (notably in litigated and compensation law cases) it is wise to ascertain if all the usual and ordinary means of treatment have been faithfully attempted; and if less than a year and a half has elapsed, whether or not a continuance of accepted measures with "reasonable certainty" will not bring about a partial or complete cure. In this connection Stimson asserts, "I think it can properly be said that an uncomplicated fracture of the shaft of the long bone of the arm, forearm, or leg will, in the great majority of cases, heal without any diminution of the earning capacity of the patient after six months, and that almost all the remainder will have reached the same condition in a year."

The average period in weeks of *total* and *partial disability* and the *deformity* in the more common simple fractures is given below; the former means inability to perform any regular work whatever, the latter meaning capacity to do some or all work up to the time of final recovery:

Bone.	Total.	Partial.	Deformity.
Jaw (lower)	3– 6	2– 4	Callus and stiffness usually disappear.
Clavicle	4– 6	2– 4	Marked callus at first; lessens in time.
Scapula	4– 8	2– 6	
Humerus	6–10	3–12	May show rotation or other changes often.
Radius, ulna	4– 6	2– 6	Moderate grades likely to show rotation changes.
Colles'	4– 6	3– 6	Wrist may show enlargement or tilting frequently.
Ribs	3– 6	2– 4	Callus and displacement vary.
Femur (shaft, neck).	10–14	20–50	Often marked, with shortening or rotation; may be permanent.
Tibia	8–12	10–20	Varies; usually slight; sometimes permanent.
Fibula	4–10	5–10	
Pott's	6–12	4–16	Marked often at first; later less, sometimes permanent.

Operative Treatment

Of late there has been a tendency to advise operation in many simple fractures on the theory that better and more perfect anatomic alignment is thus afforded. Some surgeons go so far as to counsel operation in *all* cases, in effect, to make a compound (open) fracture of every simple (closed) fracture, arguing that modern asepsis is so perfect that danger of infection is negligible. In this the writer does not agree, because the usual and ordinary methods are generally efficient, and perfect alignment is by no means necessary to a successful outcome, either as to ultimate appearance or functional capacity. There are selected cases in which a carefully performed operation is of value, but the procedure needs experience and rigid asepsis, and few general surgeons are sufficiently equipped to do as good work on bones as on abdomens or brains.

Operative Indications.—(1) Where reduction cannot be made or maintained. (2) In some spiral, very oblique, rotated, and multiple fractures. (3) Certain fractures near joints, notably when small bony fragments are detached. (4) Fractures of the patella quite often; some of the olecranon and os calcis. (5) Certain cases of non-union, or faulty or vicious union.

Compound (open) fractures do not respond well to operative interference, especially if metallic foreign bodies (plates, screws, wires) are introduced in the early stages.

Time of Operation.—In simple fractures this is generally after reactive swelling and irritation cease, usually between the first and second week; the tenth day is the time of choice in the average case.

Material Used.—*Sutures* of chromic gut, kangaroo tendon, silkworm-gut, silk, or wire made of silver, bronze (or combination) are often used. Of these, the chromic and kangaroo guts are the most valuable, in that they are absorbable and least irritating. Wire is the least satisfactory because it breaks and irritates; aluminum bronze is the best of the metallic sutures.

Suture Methods.—(1) Uniting periosteum and soft parts alone; (2) encircling the bone as by a band; (3) holes drilled through the fragments.

Metal Pins and Plates.—The method of "pinning a fracture" consists in boring a hole through the fragments with a small augur or drill and allowing the latter to remain *in situ* projecting through the skin opening; this is especially valuable in certain fractures of the neck of the femur. A small steel or silver *nail* or *pin* may be substituted. All

such devices usually become loose in a few weeks and are then spontaneously extruded or are withdrawn.

Plates made of shaped steel, silver, aluminum, or vanadium steel are screwed on the bone over the fracture line. This procedure has been advocated mainly by the English surgeon, Lane, and the plates are often known as "Lane's plates"; the operation is referred to as "plating a fracture." Oblique fractures in long bones, especially of the forearm, thigh and leg, are most often subjected to this treatment (Fig. 209). In a considerable number of cases the screws become loose, cause irritation and infection, and require removal; this may occur months after union has occurred. The author plated a forearm (radius) following vicious union of the ulna and non-union of the radius in which plate and screws required removal twenty months later, when union had long been completed and function was excellent.

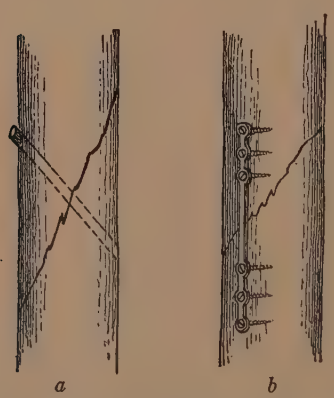


Fig. 209.—*a*, Spiking an oblique fracture; *b*, metal plating an oblique fracture.

Plating Methods.—A suitable plate and the special instruments are selected; a special bone-holder (like the Lohman) will be found of great aid. All instruments should be long handled and fingers are rigidly kept out of the wound; indeed, the use of fingers at the operating table is just as bad form as their use at the dinner table. The fracture is exposed by an incision that best conserves the adjacent structures and yet gives adequate exposure. Reduction is effected by the use of tong-like instruments and by traction and manipulation; this can be much aided by extension applied for several hours or days in advance. All intervening structures are removed and the bone edges are made rough and fresh by cureting if necessary. The periosteum is guarded carefully and carried or bridged over the fracture line as completely as possible. While the bone is properly held, the plate is applied; at least three screws are needed to prevent subsequent slipping or tilting. All bleeding is stopped and the parts are left as dry as possible.

The deeper parts are loosely sutured by catgut, and silk or silkworm-gut is used in the skin and no drainage is employed; if, however, there has been much oozing, it is safer to insert a few strands of twisted catgut

or silkworm-gut in the lower end of the wound. Dressing consists of iodin water (3j : Oj). A "window circular" or molded plaster-of-Paris splint is then applied. If drainage has been used, it is removed on the third or fourth day; if not, the dressing is undisturbed for ten days or longer. Massage can commence on the tenth day and some passive motion begins between the second and third week, and the splints can usually be discarded earlier than in non-operative cases.

Autogenous bone-plating will probably supersede metal plates in many cases.

Clamps, like those of Parkhill and other allied devices, are sometimes used, but less often since plating has been in vogue.

Failure of or Non-union.—Ordinarily we wait as long as twelve weeks before applying these terms, meaning thereby that there is practically no junction between the fragments when they are rubbed together. *Delayed union* may be said to apply to those cases where knitting is slower than usual, but yet actually there is some effort toward repair. As already stated, it is exceedingly rare and when it occurs is dependent upon:

(1) *General causes* related to the health or habits, notably syphilis, alcoholism, nephritis, diabetes, and other alterative states.

(2) *Local Causes.*—(*a*) Imperfect splintage, so that movement occurs between the fragments; very common.

(*b*) Fragments are not well coapted because of intervening soft parts (muscle, fascia, or detached bone), or where much uncorrected overlapping or rotation has occurred.

(*c*) Involvement of blood-vessels and nerves (rare).

(*d*) Infection, as in compound (open) fractures.

The essential causes are imperfect reduction and splintage.

Treatment.—The cause must first be ascertained and here *x*-ray examination is very helpful.

General causes are suitably cared for, and clinically it has been found that iodid of potash is useful even where a frank luetic state cannot be proved. Thyroid extract is valuable often, giving as much as 5 grains three or four times daily. Calcium and phosphorus also have a place and general tonics are often indicated. Open-air treatment and forced diet are quite effective adjuvants.

Local causes generally respond to one of the following:

(1) Massage is vigorously given and then the *bone edges are rubbed together* and a firmer splint applied.

(2) *Hyperemia* is induced by Bier's bandage or other device applied above the break; this is to be removed instantly if the extremity gets

very blue, cold, or painful. Those accustomed to the compression bandage can wear it for hours daily. Sometimes the bandage used above and below the break is more efficient.

(3) *Injection* of blood or serum between the fragments; from 10 to 50 c.c. can be used, and the fluid is preferably autogenous.

(4) *Drilling* the edges of the fragments to cause irritation.

(5) *Operation* only is indicated if the foregoing are inefficient after a reasonable trial (say two to four weeks), assuming that no soft or bony parts are known to intervene between the fragments. The methods named under (1) and (2) usually suffice; in all, a main essential is to reapply firm splints.

Vicious Union.—This means junction at an angle, or with much deformity, and usually is associated with much disability. This condition is frequently exaggerated in radiographs.

Causes are practically those of non-union.

Treatment is by refracture, preferably by operation, and this is followed by suture, pinning, plating, or some "stepping-down" form of operation. In the forearm, with both bones involved, it is often only necessary to correct the radius; in the leg the refracture of the tibia alone may suffice. After purposeful refracture, union is generally quicker than in the original fracture.

Excessive callus or an osseous projection can usually be removed by the chisel or forceps without affecting the fracture line.

CHAPTER VII

SPECIAL FRACTURES

Fractures of the Skull

Injury sufficient to cause skull fracture becomes important or serious only if associated with damage to the *cranial contents* because fracture *per se* often causes few symptoms and leaves little or no deformity. This fact is clinically so important that the discussion of the entire topic practically resolves itself into two groups of cases, one *with* and the other *without* signs of brain or intracranial injury.

Under Injury of the Head (see p. 450) the topic is further discussed.

Anatomy and Landmarks.—The bony cranium is arbitrarily divided into the *vertex* or *vault*, and the *base* or *basin*.

The *vertex* is that domed portion *above* a line passing from the external margin of the orbit, through the orifice of the ear, and behind to the occipital protuberance, and thence through the opposite ear orifice and outer angle of eye to the place of beginning. This includes mainly the frontal, the parietals, and part of the occipital and temporal bones. The elastic *vault* is made up practically of five bones of variable thickness, each of which has an *outer* and *inner* table separated by a spongy *diploë*.

The *base* is that portion lying *below* the above line. It mainly includes the sphenoid, ethmoid, and part of the temporal and occipital bones. This basal portion has three *fossæ*, basins, or depressions, called respectively *anterior*, *middle*, and *posterior*, and each has foramina for the passage of nerves and vessels; the *middle fossa* is quite generally involved in basal fracture.

The *vertex* shows many normal heights and depressions, recognition of which is important in excluding certain sorts of fracture (Fig. 210). These phrenologic markings are chiefly the—

Superciliary ridges, above the eyebrow.

Frontal eminences, at upper margins of the forehead.

Frontal suture, between the preceding, and it is often visible and palpable.

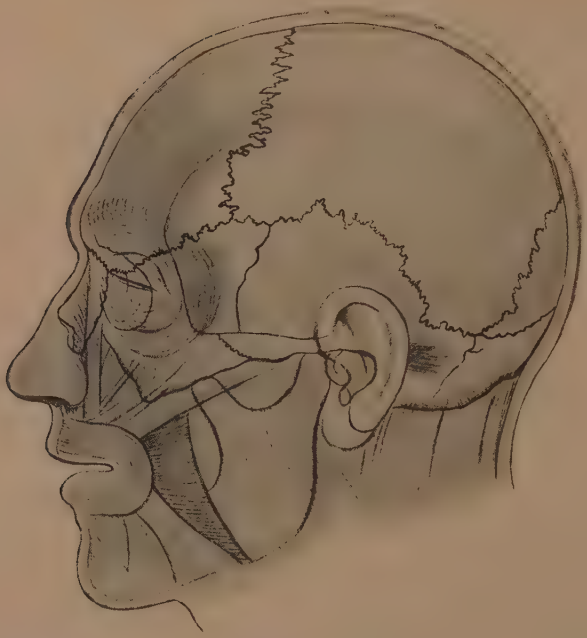


Fig. 210.—Showing the normal suture lines in the skull, with soft parts overlying same.

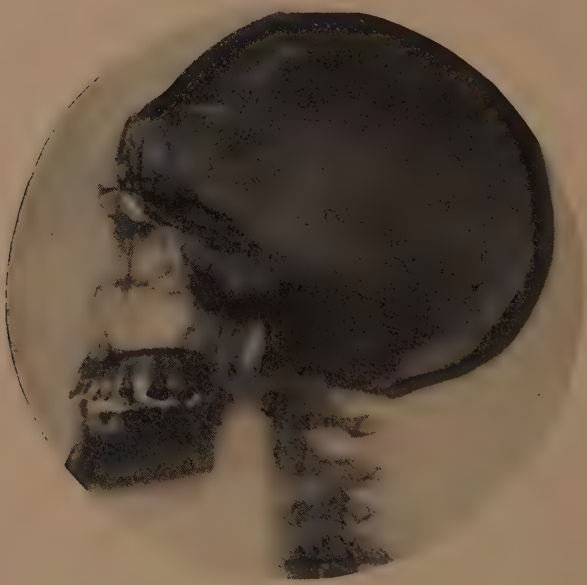


Fig. 211.—Fracture of the vault and base of the skull (frontoparietal region extending into orbit). Patient was a car conductor who hit his head against a trolley pole while leaning out of a moving car. Very few intracranial symptoms; perfect recovery; no operation.

Temporal ridges, above the ears and variably prominent.

Parietal eminences, above the preceding, and visible frequently.

Mastoid process, visible and prominent behind the ears.

Occipital protuberance, often visible and always palpable.

Occipital ridges, leading laterally from the preceding.

Fontanels, anterior and posterior, are visible and palpable in children; in some adults they persist as depressions.

Frequency.—In my table of 7631 hospital fracture cases there were 698 fractured skulls.

Of all fractures they constitute between 5 and 8 per cent. according to most statistics. From 60 to 70 per cent. of vault fractures also

Fig. 212.—Comminuted fracture of skull, frontoparietal region, spreading into base. There were no intracerebral symptoms after the initial concussion (anteroposterior and lateral views). Treatment instituted: rest, ice-bag.

involve the base, or conversely; this means that a fracture in the vault ordinarily radiates to the base, and conversely (Figs. 211, 212). From 80 to 85 per cent. of basal fractures are said to originate in the vault. The middle fossa in basal cases is oftenest affected; in the vault the parietal and frontal fractures are commonest.

Varieties.—There are various descriptive terms, but inasmuch as the main symptoms depend upon the effect produced *within* the skull, it is wisest to base the classification upon this factor because of its clinical and pathologic importance. The older division of (1) vertex

and (2) base fracture does not usually pertain because the ordinary case is a combination of both.

All are divisible clinically and pathologically into those—

(1) Without intracranial injury; (2) with intracranial injury.

Either form may involve the vault or base (or both), or be simple (closed) or compound (open).

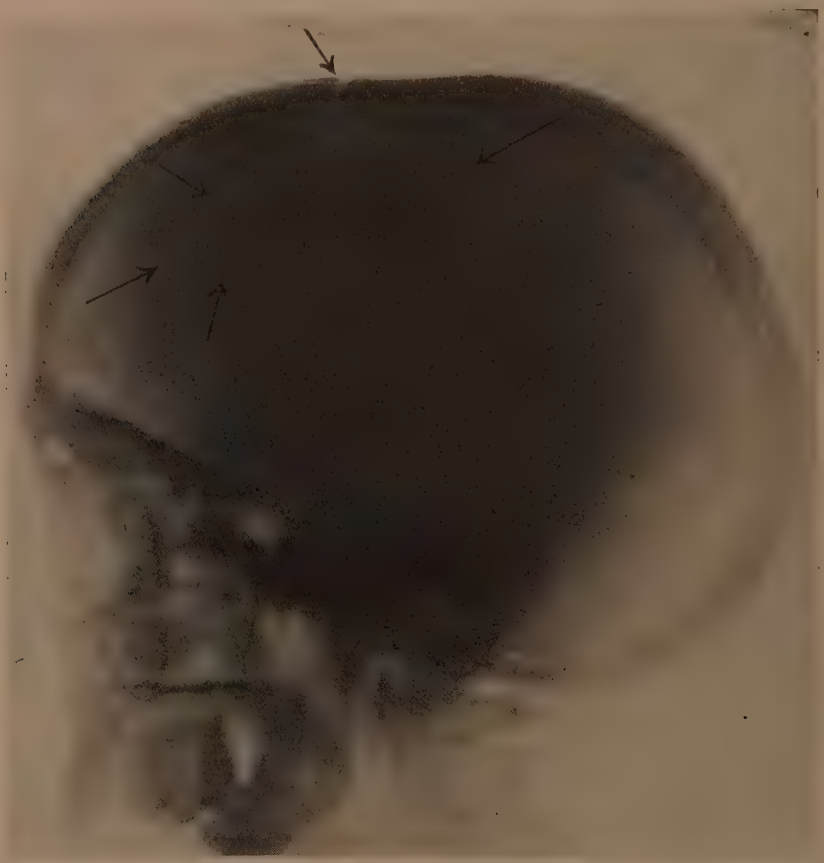


Fig. 213.—Comminuted fracture of skull, right parietofrontal region, without intracranial injury. Patient struck by a projection of a moving train (case of J. F., Post-Graduate Hospital).

(1) *Without intracranial injury* forms include that group presenting in order of frequency:

(*a*) *Linear*, *stellate*, or *radiating* fracture lines with or without a scalp wound or hematoma; commonly these occur from falls or blows (Figs. 215, 216).

(*b*) *Depression*, usually localized, involving the external or both

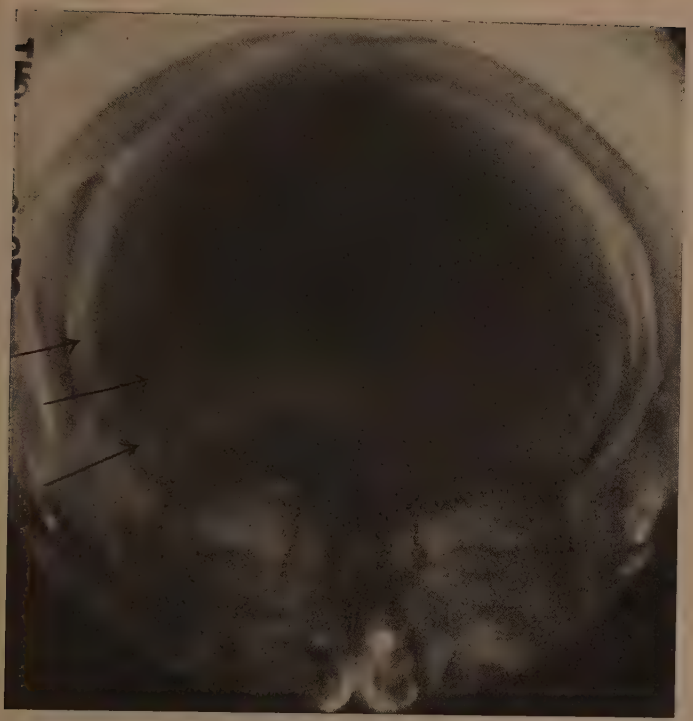


Fig. 214.—Same case as Fig. 213.

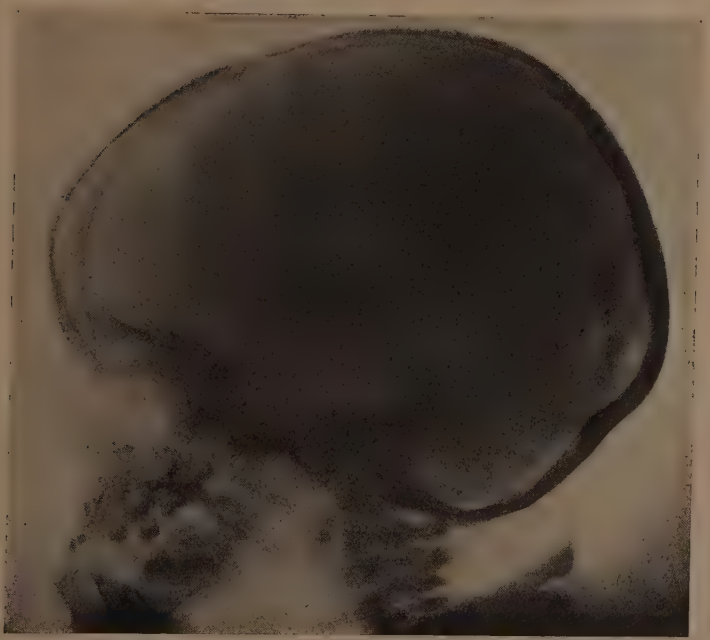


Fig. 215.—Fracture of the vault of the skull (frontoparietal region).

tables; commonly this form occurs in children (indentations) or from non-penetrating missiles (as bullets) that gouge but do not penetrate.

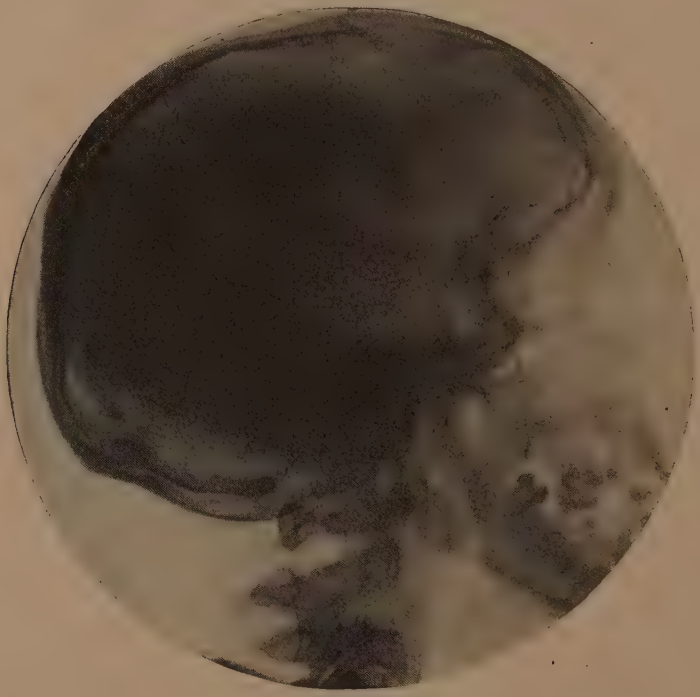


Fig. 216.—Fracture of vault of skull (frontoparietal region).

(*c*) *Lineation* and *depression* combined. A crack leading from a dent; this follows usually some direct impingement type of violence.

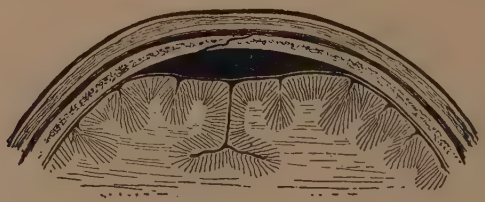


Fig. 217.—Linear fracture of skull with extradural clot.

(2) *With Intracranial Injury.*—(*a*) *Lineation* or *fragmenting*, as in the preceding.

(*b*) *Depression*, usually localized, involving the external or both tables; commonly from blows by a blunt weapon (small club, stones,

hammers) or falls on a raised object; or penetrations as by a bullet, cutting instrument, sharp-pointed tool or weapon (Figs. 217–221).

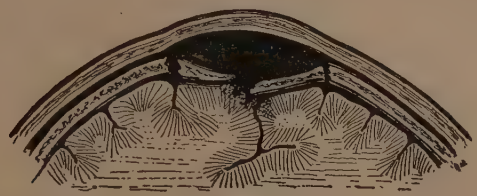


Fig. 218.—Depressed comminuted fracture of skull with hematoma of scalp and extradural clot.

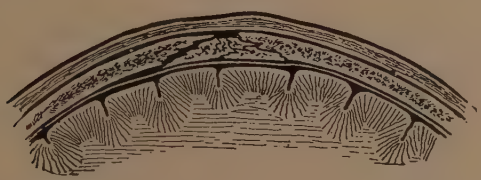


Fig. 219.—Linear fracture of skull with considerable involvement of internal table.

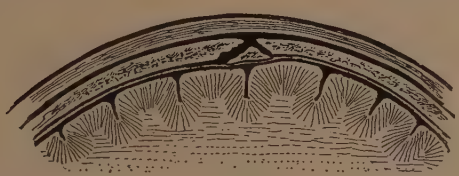


Fig. 220.—Linear fracture of skull with slight involvement of internal table.

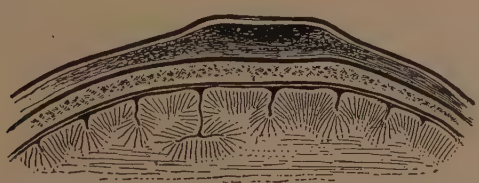


Fig. 221.—Hematoma of scalp without depression or fracture of skull.

(*c*) *Lineation and Depression Combined.*—Commonly from severe falls, blows, or large-calibered weapons; this form is generally fatal. In either group, subdivisions (*a*) and (*b*) are the commonest.

CAUSATION

This requires some statement as to the *mechanism of skull fracture* and is not difficult if it is recalled that the skull is a spheric bony box filled with a substance of somewhat elastic consistency which, in turn, is surrounded by a layer of fluid, the whole being covered by a mem-

branous envelope. The bones are irregular in shape and thickness and they are closely but not wholly immovably mortised, being buttressed by numerous ridges which radiate generally toward the base and which seem to direct impact thereto. The vault is quite elastic and capable of changing in shape without fracture. The effect of skull violence depends generally upon its (1) *source* and (2) *site*.

In the production of fracture *without intracranial injury* the source is usually one acting upon a localized area of the skull which cracks or splits (subdivision *a*); or becomes depressed or indented (subdivision *b*); carried further this force may produce the added damage named under *fracture with intracranial injury*. These are the injuries following *direct violence* generally.

If, however, the source of violence acts over a more *generalized area*, the skull then is impinged upon broadly and, being elastic, tends to elongate or widen. If the violence is not too great, no break occurs; if it is carried beyond the normal limits of elasticity, the skull bends or bursts and thus we have the so-called "bending" and "bursting" fractures. These are the injuries following *indirect violence* generally.

The theory of origin of this "bursting" (of Messemer) is based on the principle of the shortening of the diameter in the line of the violence, and a lengthening at right angles to it. Based on this, a blow received on the center of the back of the head and transmitted straight toward the middle of the forehead would *shorten* the distance between the occipital and frontal bones and *lengthen* the distance between the lateral bones of skull (as the parietal and temporal) and thus cause fracture of the latter. Conversely, if the violence was inflicted over a parietal or temporal region, the transverse diameter would *shorten* and the vertical diameter *lengthen* and the vault or base (or both) would be affected.

Under other conditions the foregoing mechanism does not prevail, but instead the bone breaks at the edge of the widest part of the depression at right angles to the line of violence; these are the *bending* fractures, so named by von Wahl.

It is improbable that undissipated violence can be transmitted from the place of receipt to a distant site directly opposite; hence so-called *contrecoup fracture* is not now given so much credence, and at all events these are but variants of the foregoing "bursting" or "bending" forms.

Fracture of the internal table without involvement of the external table is generally a supposition only, and should not be credited unless proved by exploration. Only one case is said to have been due to a fall (Stimson). Most of these cases become infected and die.

General Causes.—*Direct violence* is the commonest source, such as that following a blow or fall directly upon the part damaged or fractured.

Indirect violence acts by transmitting the violence from a distance to the place of impact, and this occurs commonly from a fall or a blow from a broad object, as from a blow on the jaw or a fall on the feet causing the ultimate impact on the base of the skull.

If the force is slight or localized, the fracture varieties named in Group 1 generally result; if it is severe or generalized, Group 2 effects generally prevail.

SYMPTOMS

These depend upon which variety exists, and, as already stated, they express themselves as (1) without or (2) with intracranial injury.

(1) **Without Intracranial Injury, Extracranial Forms.**—The *history* and *subjective signs* denote a fall or blow on the head followed by little or no unconsciousness, some shock and nausea, but no vomiting. Bleeding from the scalp may or may not have occurred. There may be complaint of *pain* and *headache* more or less localized, and stiffness and soreness of the neck and scalp muscles; *swelling*, usually circumscribed; giddiness; some patients are apathetic or may be restless or sleepless and troubled by dreams.

Objective Signs.—Signs of *shock* may exist. The *scalp* may show a circumscribed contusion or hematoma simulating a depressed fracture; differentiation is made by noting that the edges of the latter are not hard or irregular and they can be rubbed away, and that pressure made in the center shows normal skull beneath. Through a wound the fracture may be visible or palpable; if the latter, the torn periosteum may be mistaken for a fracture unless the wound is widely retracted. A normal suture line may also deceive; but it can be differentiated by its known position, its regularity, and by the fact that bleeding over or from it can be wholly sponged away, while that from a fracture line oozes despite sponging.

Ecchymosis may appear at a distance from the fracture site, especially if the case is seen from one to seven days after the accident; this is typically seen in the eyelid or over the mastoid in basal affections.

Orifice bleeding denotive of basal involvement may appear in the (*a*) *conjunctiva* in a more or less crescentic form, usually on the superior or internal margin; if due to direct contusion and not fracture it is more diffuse, less geometric, earlier in onset, and associated with adjacent contusion signs.

(*b*) *Nose.*—Hemorrhage therefrom is variable in amount and usually unilateral.

(*c*) *Pharynx.*—May show trickling blood or punctate or ecchymotic markings.

(*d*) *Ear.*—This may show dry or fresh blood, and less often there is escape of straw-colored cerebrospinal fluid. Blood escaping from the ear, without fracture, may be due to a ruptured ear-drum, wounds of the ear canal, a transmitted blow from the point of the jaw, or it may drip into the external meatus from adjacent wounds.

Periosteum.—This may be torn, infolded, or undamaged.

Bone.—There may be a single linear crack, or these may be stellate or numerous enough to resemble a "cracked egg shell." Depression or indentation of varying degrees may be seen or felt. Percussion may give an altered note over the broken bone. Temperature, pulse, and respiration are usually little if any affected.

(2) **With Intracranial Injury, Intracranial Forms.**—*History* and *subjective signs* indicate a blow or fall on the head sufficient to produce *concussion* (mild, moderate, or severe), as shown by immediate unconsciousness and vomiting. On "coming to," there is *giddiness* or *dizziness.*

There may have been *involuntary passage* of urine and feces.

Prostration is more or less complete.

Pain in the head may be local or general.

Bleeding from the wound or orifices may appear.

Special sense disturbance is frequent, especially of hearing and sight.

Sensorium.—*Confusion* and perhaps irrationality are present at times.

Memory is usually deficient from the instant of the accident until unconsciousness disappears, and often the patient has no accurate idea as to how the injury occurred.

Motor System.—Weakness or loss of power in a limb or limbs may occur.

Sensory System.—Rarely there is tingling, burning, or altered sensations in a limb or limbs.

In another group of cases there will be elicited a history of:

(1) Slight initial unconsciousness with an apparently *normal latent interval* followed within hours or days by unconsciousness, paralysis, and signs of intracranial pressure. All such cases show *some* symptoms in the interval period, although these may be unobserved by the patient or laity. This is the sort of case in which the patient

may reach home unattended and later is found comatose. Such patients are not infrequently alcoholic when hurt and are regarded as drunk until the onset of some differentiating signs.

The interval after an accident in which such a condition may appear is variable; some of these are the so-called "traumatic late apoplexy" cases of Bollinger and others about which recent controversy has arisen. It is unreasonable to expect that the effect of an injury to the head will be long delayed, and for that reason, even in this rare and disputed class, the symptoms must not (*a*) be delayed beyond a few weeks; (*b*) the interval must be filled by some connecting and continuing symptoms; (*c*) there must be no other adequate cause, like arteriosclerosis or its associates; (*d*) the injury must be adequate.

(2) Another class of cases show continuing total or partial unconsciousness that deepens to complete coma, with usually a corresponding advance in other symptoms.

Objective Signs.—There may be outward signs of *shock;* the patient will be conscious or unconscious; rational or irrational; and occasionally there may be visible tremor, or clonic or tonic spasms of the face or limbs, or both.

Scalp.—Generally this shows a wound or hematoma.

Ecchymosis.—This may appear in the eyelid, mastoid, or suboccipital region.

Orifices.—Bleeding from the ear occurs commonly; or it may be nasal, pharyngeal, or conjunctival. Less often cerebrospinal fluid or brain tissue exudes, usually from the ear. Infrequently, and some days after the injury there may be a discharge of rather a large amount of yellowish fluid from an orifice; usually this is presumed to be serum or cerebrospinal fluid, and it often relieves headache or fulness or deafness.

Periosteum.—This often is torn or otherwise damaged.

Bone.—It will be cracked, indented, or depressed more or less regularly and extensively.

General State.—*Shock* signs exist.

Temperature.—Generally it is elevated and may reach 105° F. in unfavorable cases.

Pulse.—Usually it is normal or rapid at first; it slows and becomes tense later as intracranial pressure proceeds, and usually then beats below 70 and may reach to 40 or less.

Respiration.—This is normal or rapid at first; later, breathing is slowed (4 to 12) and often is stertorous, and as the medulla becomes more and more involved the Cheyne-Stokes type appears.

Blood-pressure.—This is normal or slightly affected at first; later it rises and is one of the best signs of advancing pressure.

Choked Disk.—It is present only in existing intracranial pressure due to blood or edema; it is an important symptom.

Fig. 222.—Spinal puncture (upright position) in the second lumbar interspace just above the iliac crests.

Spinal Puncture.—This reveals blood in basal fractures, but it is rather unreliable, because the needle in being introduced may be the source of the so-called "bloody tap" (Figs. 222, 223).

Special Senses.—These may be blunted or abolished; hearing, sight, and speech defects are the commonest.

Fig. 223.—Spinal puncture (dorsal position) in the second lumbar interspace just above the iliac crests.

Sensorium.—This shows more or less impairment.

Motor System.—There may be impaired or abolished functions of a limb or muscles. This may come on at once in severe cases; usually it is gradual and shows first as a localized twitching or spasm (affecting

one side of the face, the arm or the leg) and may proceed to tonic or clonic convulsions of the same part and gradually extend to the others on that side of the body, and may finally end in paralysis of one-half the face, one limb (monoplegia), or an extremity (paraplegia).

Sensory System.—There may be diminished, absent, altered, or normal sensation.

Reflexes.—These may be exaggerated at first, later diminished or abolished. The most important are the patellar, Achilles, cremasteric, and pupillary. The latter early may be unaffected; later the pupil on the affected side is generally dilated and the eyeball is turned toward the lesion. A convergent or divergent strabismus may exist.

X-ray.—Radiating fractures, out of ordinary view or touch, are sometimes shown.

Determining Symptoms.—*Compound* (*open*) *fracture* is usually visible and always palpable.

Hematomas should be incised if at all confusing.

Basal fracture exists if the history and subjective symptoms are rationally adequate and if examination discloses some of the following in association:

Subconjunctival hemorrhage,
Ecchymosis of eyelid,
Eyeball tension increased,
} in { fractured anterior fossa,
via broken orbital plate of the frontal,
or bleeding along the sphenoidal fissure or optic tract.

Nasal hemorrhage,
Nasal cerebrospinal oozing,
Olfactory involvement,
} in { fractured middle fossa,
via the cribriform plate of the ethmoid.

Ear hemorrhage,
Ear cerebrospinal oozing,
Pharyngeal hemorrhage,
Auditory involvement,
Postmastoid ecchymosis,
} in { fractured posterior fossa,
via the petrous portion of the temporal.

The ear shows signs oftenest; next, the nose.

About six out of ten fractures affect the base, and eight out of ten of these begin as vault fracture.

INTRACRANIAL DAMAGE

This results from pressure due to (1) bone or foreign bodies; (2) blood, serum, or inflammatory exudate; (3) laceration of meninges or brain.

(1) **Bone-pressure** usually is not great enough to cause immediate symptoms. If it is, a compound (open) depressed fracture is generally

the easily recognizable cause. Missiles are usually removable, but may do no harm if small or in a "silent" or non-functionating area.

(2) **Blood** or **serous pressure** is the usual initial cause and the pressure effects then depend upon the location and extent of the effusion. It may appear promptly; later in onset it may indicate an inflammatory exudate.

Sites of Pressure from Blood.—(*a*) *Above Dura.*—The so-called *extradural hemorrhage.*

Here it is commonly from a torn meningeal vessel, usually the anterior branch of the middle meningeal.

This is the common form of "hemorrhage of the brain."

(*b*) *Under Dura.*—The so-called *subdural* or *cortical hemorrhage.* It occurs from torn vessels on the brain surface generally, or from sinuses.

It is the second most frequent variety and is difficult to differentiate often from the following form.

(*c*) *Within Brain.*—The so-called *cerebral* or *central* or *medullary hemorrhage.*

Generally this is ventricular or medullary in origin and it is an associate of fatal injuries, and recovery practically never occurs when injury is the cause. Ordinary apoplexy is the usual producing factor.

(3) **Laceration of the Meninges or Brain.**—This is an accompaniment of severe compound depressed fractures, oftenest from perforations and bullets; or it occurs from localized extensive depressions or "bursting" fractures. It shows itself mainly by coma or semicoma and irritation with more or less delirium and rise of temperature.

A considerable amount of pressure or effusion may occur before any local or general pressure-signs appear, and for that reason a suspected case must be carefully watched for the first signs of localization. In some patients the exact situation at the onset may be puzzling, and yet within an hour local pressure may so manifest itself as to almost mathematically determine the location of the lesion.

Diagnosis of Hemorrhage.—(*a*) *Above Dura, Extradural Hemorrhage.*—This exists if the history and subjective signs are rationally adequate and if the following, in order of their significance, appear: (1) Latent period following initial concussion; (2) advancing unconsciousness; (3) changed temperature (rise to 100° F. or over); pulse slowing (below 70); respiration slowing (or approach to stertor); (4) localized twitching, spasm or convulsive movements, especially significant if it begins in a distal part and advances proximally, or the reverse; (5) flaccidity, rigidity, or paralysis of a limb or other part of

known innervation; most important when the motor-cortical area is involved; (6) rising blood-pressure as shown by the sphygmomanometer or choked disk, or both.

(*b*) *Under Dura, Subdural Hemorrhage.*—This exists if the history and subjective signs are rationally adequate and if the following, in order of their significance, appear: (1) Persisting unconsciousness that is stationary or deepening; (2) signs of fractured base; (3) changes in temperature, pulse, and respiration, as in (3) of the preceding variety; (4) paralysis of one side of the face or one limb; (5) involvement of the reflexes; (6) signs of rising blood-pressure, as in (6) of the preceding variety; (7) cerebral irritation as shown by restlessness or delirium.

(*c*) *Within Brain, Cerebral or Central Hemorrhage.*—The signs are exaggerations of the foregoing and the condition is grave from the outset; hemiplegia is the common manifestation and ordinary apoplexy is the existing cause in cases that recover, as those due to injury are promptly fatal.

DIAGNOSIS

Other conditions capable of causing unconsciousness or actual coma must be excluded, such as—

Alcoholism.—Odor on breath and vomitus; pupils usually equal and dilated; general and not local flaccidity or paralysis usually exists; patient frequently can be aroused by slapping soles, supra-orbital nerve pressure, or the "grid-iron" (rubbing chest vertically with knuckles to irritate the intercostal nerves); pulse generally bounding and rapid. It must be remembered that the conditions may and often do coexist.

Apoplexy.—Coma and paralysis usually earlier in onset and more profound; hemiplegia and aphasia common; age and adequate causes of hemorrhage usually present. Often a fractured skull occurs from the fall incident to a "stroke," and death is due to the latter and not to the former.

Uremia.—Coma not usually profound; appearance often suggests nephritis; pupils even, sluggish, and dilated; urine albuminous, with casts.

Opium.—Habitué signs; patient is arousable; pupils small and fixed; respirations low; reflexes slow or absent.

TREATMENT OF FRACTURED SKULL

This depends obviously on the extent of the injury, notably as to the extent of intracranial involvement.

All suspected cases should be kept exceedingly quiet during the early stages particularly, and the period of convalescence should be prolonged until objective and verifiable subjective symptoms abate. Unconscious patients should be catheterized every eight hours during the first day and every twelve hours thereafter. Urotropin in 5-grain doses should be given every four hours for the first week or longer.

(1) **Cases Without Intracranial Injury.**—*General Measures.*—Patient is abed; a vigorous cathartic is given; diet is restricted; an ice-bag is given for headache; sedatives are sparingly used when necessary, the bromids preferably. Urotropin (5 to 10 grains) every four hours is advisable.

Local Measures.—Cold compresses (saline solution, boric acid, alcohol) may be used over *contused* areas of the scalp; *hematomas* ordinarily subside on pressure, or later are carefully aspirated or incised only if necessary.

Wounds have iodin poured into and about them and a considerable surrounding area is shaved and every effort made to prevent infection. Suturing of the periosteum is usually unnecessary and inadvisable. Scalp wounds are loosely stitched or left open, and drainage by twisted strands of catgut or silkworm-gut is provided; rubber tissue or tubing or thin gauze may also be used. If the wound edges are bruised, irregularly torn, or otherwise lacking in vitality, no suturing is advisable; the cavity is then loosely packed with gauze. If the skull is much indented, cracked, and *depressed*, it is elevated by the edge of an instrument, and in so doing it may often be found that the inner table is more involved than the outer. Detached fragments causing pressure are removed; they may be safely left if they remain elevated and have even only a slight attachment by periosteum or jamming. Bleeding from the bone is stopped by pressure of instruments, gauze or bone-wax; ordinarily it ceases spontaneously.

Bleeding orifices are *gently* instilled with one-half strength ($3\frac{1}{2}$ per cent.) iodin or 10 per cent. argyrol solution; the mouth is kept clean with Dobell's or other alkaline solution. Patients are cautioned against violent nose blowing.

(2) **Cases With Intracranial Injury.**—This often can be inferred from the history, the subsequent progress, and the examination findings, notably where a compound (open) fracture exists. It is prudent and often helpful to shave the entire scalp, and then careful comparative palpation or auscultation may better reveal the site of the lesion.

General and *local treatment* is the same as for the preceding; com-

plications or increase of symptoms are watched for and appropriate measures are then used. Shock is met if present, but stimulants are used cautiously if at all.

Concussion.—Unconsciousness therefrom is *temporary always;* if it lasts more than a few hours, the condition then is one of *contusion, laceration,* or *hemorrhage,* provided other appropriate symptoms are also associated.

Unconsciousness.—No effort should be made to arouse the patient, as this of itself is not a serious symptom and in many cases it has persisted for weeks, ending in complete recovery. I know one case where it lasted sixty-two days and the patient is alive and practically well.

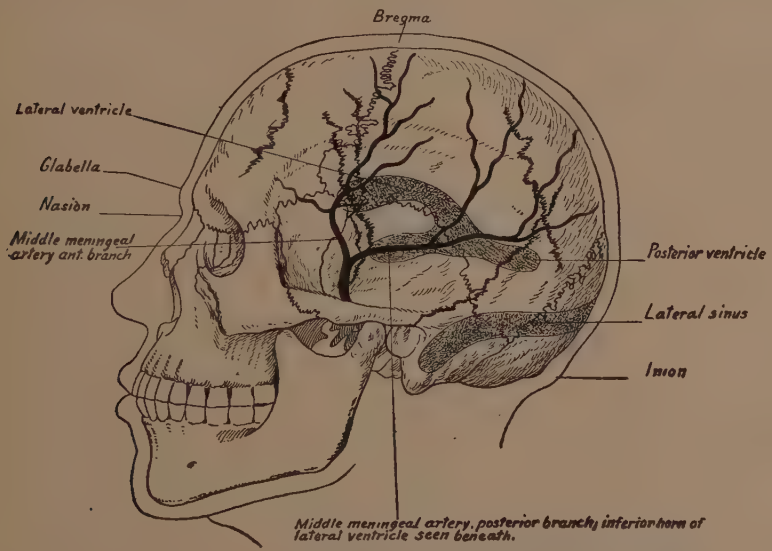


Fig. 224.—Showing relation of meningeal vessels, lateral ventricles, and lateral sinus.

Contusion.—This is inferred if the stage of unconsciousness is prolonged beyond that of concussion; there may be no other symptoms indicative of this, and in a degree it can be regarded as an advanced grade of concussion. It requires no special treatment unless local (focal) or general signs of pressure appear.

Laceration.—This is inferred if there is much restlessness, irritation, or delirium. Some rise of temperature is always present; it generally ranges between 99° and 101° F., but it may reach 105° F. in severe cases. Pulse and respiratory changes are less common. Paralysis is slight and temporary if present at all. Delirium tremens is sometimes hard to differentiate. Meningitis signs occur occasionally. No special treatment is indicated unless signs of pressure appear.

Hemorrhage.—This may be considerable and yet at first give signs of concussion, contusion, or laceration until it becomes large or localized enough to indicate *intracranial pressure* or *compression of brain.* It may be very slight in certain areas and yet show indubitably by focalizing signs; this is notably so over the motor area, about certain cranial nerves, and in the region of the medulla or pons (Figs. 224, 225).

General signs of pressure have already been mentioned, and attention is again called to the diagnostic value of the progress of symptoms and changes in the temperature, pulse, respiration, reflexes, and muscle power. Blood-pressure and eye-ground examinations are here of greatest value. Spinal puncture may prove to be the one best sign of basal involvement. Local signs from the beginning may be marked enough to make treatment unavailing; but if the symptoms are *focal* and within reach, operation is advisable (Fig. 225).

Fig. 225.—Meningeal hemorrhage clot with fracture leading into base.

In all forms *x*-ray examination may prove of great value in accurately locating the lines of fracture.

Operative Indications and Methods.—Two main sources of pressure require relief, namely: (1) *bone* or *foreign bodies* and (2) *effusion* (blood, serum, or pus).

(1) *Bone* or *foreign body pressure* usually accompanies obvious compound (open) depressed fracture. Where possible, no fragments of bone should be removed, as most of them are viable unless wholly detached. No anesthetic is needed unless the patient is conscious; ether is the best.

Technic.—Preliminary iodin cleansing of the entire shaved scalp. Ears plugged by sterile cotton; tourniquet in place (Figs. 226, 227). Wound enlarged if necessary; it is needless and unwise to incise the

intact scalp to trace the limits of fracture throughout. It is unnecessary to trephine unless the bone cannot be elevated by the edge of a

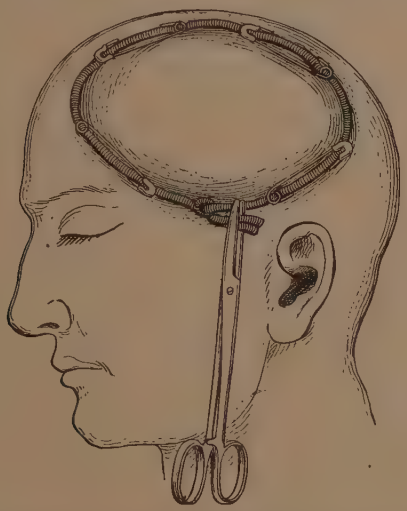


Fig. 226.—Rubber tubing passed through safety-pins previously introduced through all the layers of the scalp. This acts as a hemostat in bone-flap skull operations.

chisel or similar instrument; if trephining is needed to elevate the fragments, let the hole be small and at the margin of the depression in

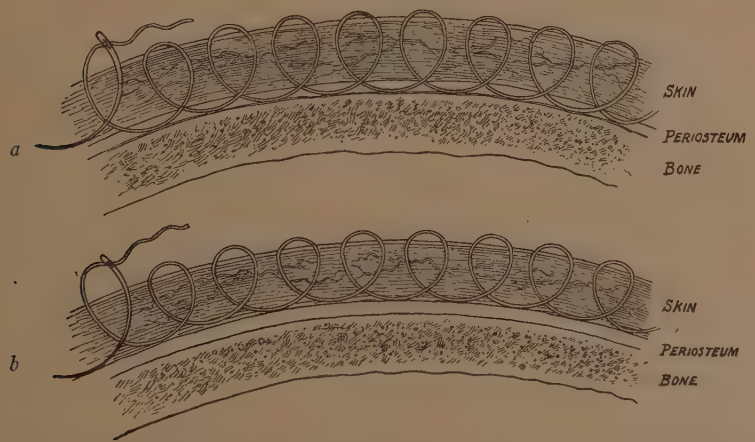


Fig. 227.—Haidenhain hemostatic stitch used to encircle the soft parts preparatory to bone-flap skull operations: *a*, Properly introduced, reaching *under* periosteum; *b*, improperly introduced, reaching *above* periosteum.

sound bone. Small amounts of depression do no harm and perfect restoration of contour is not required (Figs. 228, 229).

Bleeding may be free from the bone, but punching or nipping the diploë usually stops it; packing with gauze or wax may be needed rarely. Clotted blood under the skull should be gently scooped out enough to bring the dura and pulsating brain to the surface; it is unwise and unnecessary to try to get all the clot out. Some of it can be floated out by gentle saline irrigation. Visible sources of bleeding (meningeal vessels) are caught by forceps or controlled by gauze wicks. If blood wells up from beneath, it cannot be reached directly, but can be drained

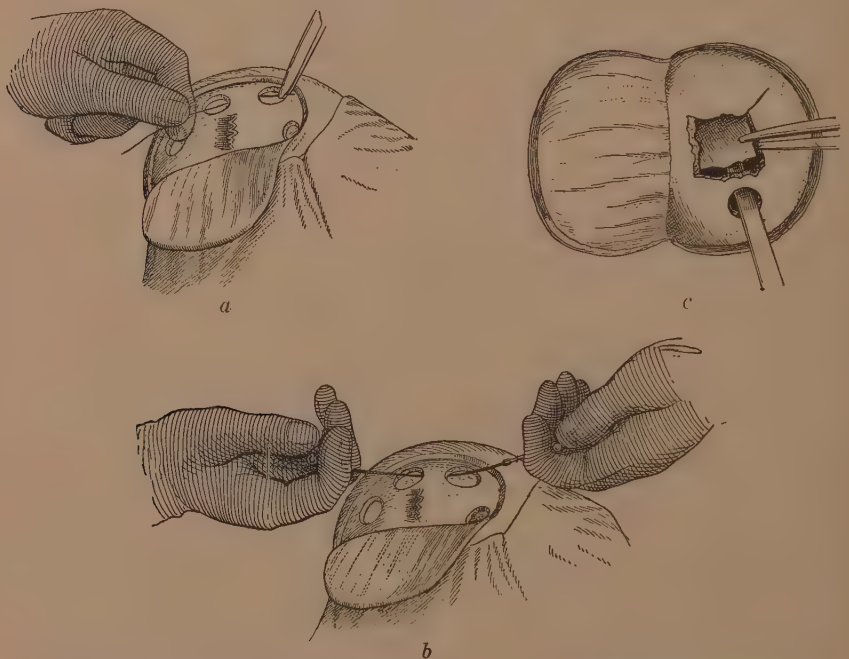


Fig. 228.—Compound depressed fracture of skull: *a*, Passing Gigli saw through multiple trephine openings; *b*, preliminary Gigli saw-cut to fashion bone-flap; *c*, elevation of a depressed fragment by instrument passed through a trephine opening.

in part by gauze; this usually signifies basal involvement of bone or brain. Nothing should be done to a torn or otherwise damaged cortex.

Dura, if torn, is loosely sutured by catgut or fine silk; if untorn, it is undisturbed, and it should not be incised if of a normal pearly color and if the brain pulsates.

Closure is made with drainage and loose suturing of the scalp by silk, silkworm-gut, linen, or horsehair. Rubber tissue or catgut or silkworm drains are used where little drainage is required; gauze is employed otherwise to stop oozing. The drains reach *to*, but not *through*, the dura.

Fig. 229.—Compound depressed fracture of the skull: *a*, Rubber tubing tourniquet placed, wound enlarged; *b*, skin-flap and periosteum retracted; *c*, depressed bone being elevated.

Dressing is firm, and in the restless or alcoholic is often reinforced by starch bandages.

Assuming that *intracranial pressure* from blood or other effusion exists, operative interference may be necessary, and becomes indicated in the presence of (*a*) focal or localization evidences, (*b*) advancing intracranial pressure.

(*a*) *Focal or Localization Cases.*—In the absence of a compound (open) fracture, shaving the entire scalp may disclose some external evidence of hematoma or ecchymosis to corroborate those symptoms already manifest.

The commonest sites of clot-pressure are near the meningeal vessels, notably the anterior branch, and these are reached by incisions planned as indicated in Figs. 224–230.

Fig. 230.—Subtemporal decompression of skull. Vertical line shows plane of intermuscular incision. Dotted line shows area of bone to be removed. The incision through the scalp may be vertical or crescentic.

The approach can be made through the ordinary circular trephine opening enlarged by the rongeur; preferably it is by the bone-flap method shown in Fig. 231.

This latter has the advantage of providing wide exposure without loss of bone. Conditions are then met with as indicated previously in speaking of *pressure by bone* or *foreign bodies.*

(*b*) *Advancing Intracranial Pressure Cases.*—Localization evidence in these is undefinable, as the pressure is wide-spread and the idea is to afford relief by providing a drainage opening in the skull; such a procedure is known as "decompression."

Subtemporal decompression is the method advocated by Cushing,

and it is quite commonly employed because it is easily done and the trephine hole is later partly covered by the temporal muscle (Fig. 230).

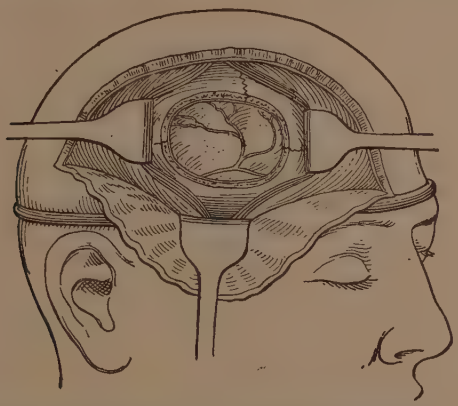


Fig. 231.—Subtemporal decompression of skull (flap method). Fibers of temporal muscle have been separated and the original trephine opening has been enlarged to expose the meningeal vessels.

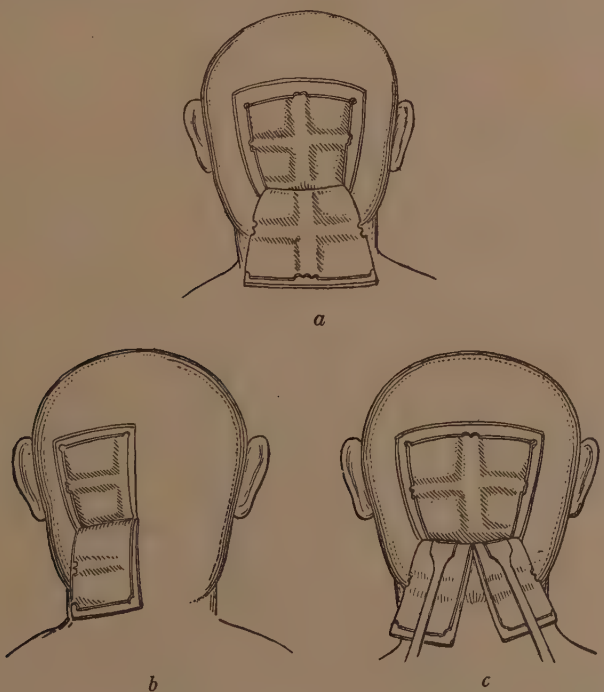


Fig. 232.—Occipital osteoplasty: *a*, Single flap; *b*, unilateral flap; *c*, bilateral flap.

Technic.—The semicircular incision is made (Figs. 230, 231) midway between the orbital edge and the ear top, and it exposes the tem-

poral muscle, the uncut fibers of which are then separated and a trephine button removed. The opening is then enlarged by the rongeur to the size of half a dollar or a dollar; the dura is slit; a gauze or rubber drain is placed down to the dura; the muscle-fibers are allowed to fall into place or are loosely stitched; the skin is sutured. Drainage is maintained forty-eight hours; longer if the discharge seems to so warrant.

In other cases (as in some basal fractures) the *suboccipital decompression method* is advisable, and it is similarly performed (Fig. 232). Occasionally decompression is made bilaterally.

Some surgeons advise either of the foregoing as routine measures in *every* case showing compression evidences; others more properly reserve it for that class of cases seemingly unbenefited by ordinary means. Cushing reports 13 recoveries in 15 cases. Such good results as this are seemingly not attained by other surgeons, and in my experience I have not observed that it is markedly beneficial in comparison with other methods. Many cases would get well without operation, and I do not believe that those operated upon are less likely to develop early or later complications.

COMPLICATIONS AND RESULTS

Cases that early recover from objective signs generally get well; the majority of fatalities occur within the first forty-eight hours. Cases in Group 1 practically recover completely. Fifty per cent. at least of basal fractures live; many of those surviving recover in every respect (Figs. 233, 234).

Sepsis and Meningitis.—These usually occur in compound (open) cases or fracture of the base with infection through the orifices. Preliminary antisepsis is the best prophylactic.

Abscess of Brain.—This is rare and is usually seen in cases of localized depression or follows compound infected forms; I have known such a complication to follow a fracture of the middle fossa in a patient with an old and partly quiescent otitis media.

Delirium Tremens.—This is very common, and may itself lead to edema of the brain (alcoholic wet brain), making differentiation from traumatic intracranial pressure difficult or impossible.

Pneumonia.—An early *lobar form* is occasionally seen, especially in alcoholics. A later *hypostatic form* is common in the aged or depleted.

Neural Involvement.—The *seventh* or *facial* is most often affected, giving total or partial unilateral paralysis of the face; it generally is

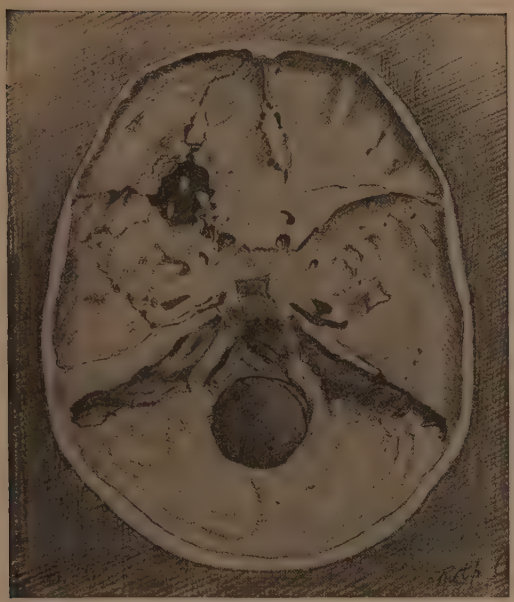


Fig. 233.—Harvard "crow-bar case." Note wound through anterior fossa on left. Patient lived many years after the accident.

Fig. 234.—The Harvard "crow-bar case," with subsketch showing relative size of skull and crow-bar; the latter penetrated palate, orbit, and vault.

due to pressure from effusion and commonly disappears, although months may elaspe.

The *eighth* or *auditory* may likewise suffer, causing unilateral deafness; this also is generally recovered from wholly or in part.

The *third* or *motor oculi* occasionally is affected, producing internal squint, unilateral ptosis, and a dilated and inactive pupil; it may in part be permanent.

The *sixth* or *abducens*, if involved, gives internal strabismus that may persist.

The *olfactory* and *glossopharyngeal* are rarely involved.

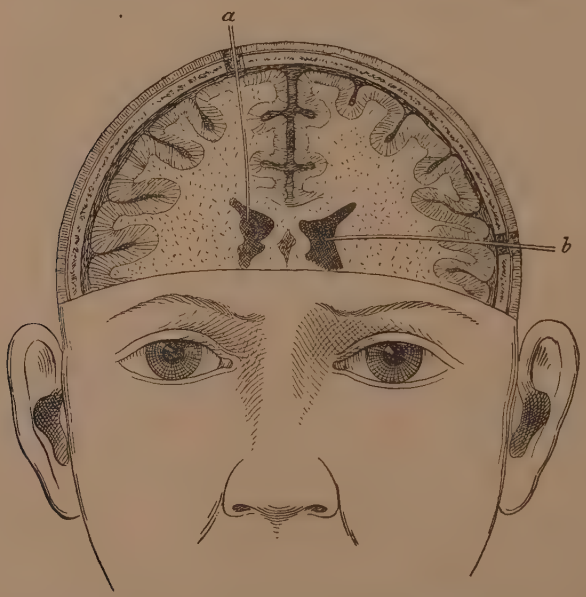


Fig. 235.—Aspiration of lateral ventricles: *a*, Vertical approach; *b*, lateral approach.

Speech defects are generally overcome.

Paralysis in a limb rarely lasts.

Memory may be defective for a time, but usually is wholly or partly regained; defects are most common respecting recent events, especially as to figures. Amnesic impairment is more likely if the left inferior frontal part of the brain has been involved in right-handed persons; the reverse obtains in left-handed persons.

Instability in the *muscular system* may be indicated by unsteadiness, incoördination, some staggering and inability to maintain equilibrium when off the ground or in the dark. This is commonest in alcoholics and the aged. A good deal or all of it may eventually disappear. It

is most likely in basal cases, especially if the middle or posterior fossa has been involved.

Mentally there may be irritability; a tendency to tears or laughter; strange likes and dislikes; incapacity for alcohol or tobacco, or the reverse. Like the foregoing sequelæ, most of these abate in time.

Insanity.—This is a very rare sequel, even in the presence of marked original damage; less than 2 per cent. of known insanity follows head injury.

Neurasthenia and **hysteria** are generally most marked in the litigated cases and in those in which the objective signs of injury are least marked. Most of these do not subjectively recover until financial expectancy is realized.

Cysts as remnants of blood absorption occasionally form, and later may give rise to signs of tumor.

Epilepsy as a pressure or irritative sequel of head injury is not now regarded as so frequent a complication, doubtless owing to—

(1) Wider knowledge as to the origin of the disease.

(2) Experience gained through the large number of so-called "traumatic cases" operated upon, in which none of the expected local damage was found.

(3) Because of the very great number of head injuries and the relatively few cases of epilepsy arising therefrom.

Fig. 236.—Hernia cerebri following exsection of skull for compound depressed fracture.

(4) Because the brain can readily accommodate itself to changes in pressure; according to Stimson this pressure must amount to about 2 cubic inches of sudden depression in the adult skull before permanent symptoms of general compression arise.

If epilepsy is to be regarded as traumatic in origin, it is most likely to occur if the motor area has been effected by the injury; then the symptoms begin with *local* irritation of the affected part (Jacksonian epilepsy), followed by general spasms and unconsciousness—the "fit," in other words. It is said also to arise from *adhesions* due to a *scar* in the cortex or dura, or between the same; or between the dura and the skull or scalp. This seems less probable than the former named source. Children are prone to epilepsy from so many causes that its origin from

injury is more doubtful than in adults, especially as a child's skull can more readily adapt itself to enforced changes.

Bony defects from depression or operation are generally replaced by fibrous tissue over the central part, the edges being smoothed and hardened by a more osseous material. After a lapse of years this fibrous covering apparently hardens, and may even become bony in consistency over a space as large as 2 inches square. In children such gaps are more likely to be filled in earlier and more uniformly.

Pulsations can often be seen and usually are felt; they may be marked and annoying at first, but later grow less.

Hernia of the brain is rare (Fig. 236).

Lower Jaw Fracture

The inferior maxilla is more commonly broken than any other bone of the face. In my statistics 228 cases occurred; a percentage of 7.1

Anatomy and Landmarks.—Practically the entire bone is palpable.

Ramus.—The perpendicular portion ending above in the *condyles* articulating with the *glenoid cavity;* in front of this is the *sigmoid notch* capped by the *coronoid process.*

Angle.—Lower back part of the ramus, often prominently visible.

Body.—Transverse horseshoe-shaped part, with the upper *alveolar border* for sixteen teeth.

In children and the aged the ramus and body form an acute angle; in adults, a right angle.

Causes.—*Direct violence* is the common origin, and this is usually from a blow or fall received on the chin, or less often on the side of the jaw.

Indirect violence is a very rare source; the condyle occasionally is broken by transmitted force from blows upon the chin.

Muscular Violence.—Coronoid process fractures alone may thus occur; this, however, is a clinical freak.

Sites and Varieties.—(1) Region of incisor teeth commonest; (2) condyles next most frequent; (3) ramus least frequent (Fig. 237). The break may be *multiple,* usually on either side of the middle border, as from heavy blows, falls, or bullets.

Partial fracture of an alveolar border from teeth extraction is not infrequent.

The vast majority of fractures are in the teeth-bearing area and are vertical or oblique in direction.

Compound (open) forms are not uncommon, and the wound may be in the skin or gums.

Symptoms.—(1) Visible deformity and disability, showing either in the face, mouth, or teeth. (2) Crepitus and false motion, best elicited

Fig. 237.—Fracture of the lower jaw in front of the angle.

by bidigital palpation inside and outside the mouth. (3) Later, swelling of face, gums, and glands; salivation, stomatitis, and abscess are common in neglected cases.

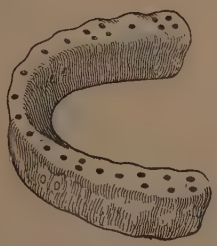
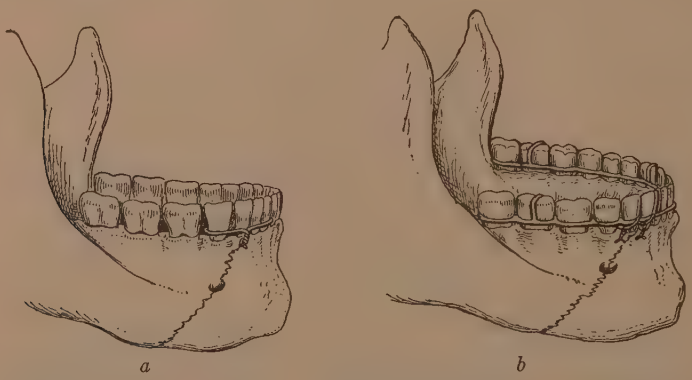


Fig. 238.—Interdental splint for fracture of the lower jaw.

Treatment.—*Reduction* is by pressure manipulation that aligns the teeth.

Immobilization is by (1) *bandages* (four-tailed or others), binding the jaws together. Two broad rubber bands act well instead.

(2) *Splints.*—Wire, thread, plaster of Paris, leather, or metal so devised as to lock the teeth or embrace the chin and pull it back and up. Wire or thread twisted about the intervening teeth answers in ordinary cases (Fig. 239).



a *b*

Fig. 239.—Wiring fracture of lower jaw: *a*, Including a few teeth; *b*, including many teeth.

(3) *Special splints*, interdental in type like those of Matas, Kingsley, or Moriarty; or those specially molded by an oral surgeon (Figs. 238, 240).

(4) *Operation.*—Exposing the fracture through skin incision and suturing it by gut or wire, or plating it.

Fig. 240.—Matas' splint in fracture of the lower jaw.

In all forms, one or more teeth may need extraction for reduction or feeding. Loosened teeth generally tighten. Particular attention must be given to keeping the mouth clean. Nasal bleeding may be an accompaniment.

Union is complete in four to six weeks, and before this part or all of the splintage may be removed.

Results.—Usually these are good, and even in the presence of considerable oral deformity the outward appearance and function is excellent. Dental treatment may be required later if the teeth are damaged. In patients with pyorrhea, osteomyelitis and sinus formation sometimes occur.

Disability.—Total, four to six weeks; partial, two to four weeks.

Upper Jaw Fracture

The superior maxilla is infrequently broken except when it is associated with other fractures, as of the nasal or malar bones.

Causes.—*Direct violence* is at fault always; commonly this is from blows, falls, kicks; automobile, bicycle, and vehicular accidents.

The alveolar border or one of the processes is usually involved.

Symptoms.—Visible deformity and disability vary; usually there is a good deal in the region of the cheek and nose, and often bleeding from the mouth and nose occurs. Ecchymosis of the hard or soft palate is a corroborative sign. Facial emphysema is common. Crepitus and false motion are variable. Teeth are often loose, broken, or missing.

Treatment.—Like that of lower jaw, this is by a bandage or special splint; reduction may be difficult in complicated cases.

Union is complete in four to six weeks.

Results.—Practically perfect as to function. Deformity of the teeth or nose may persist.

Disability.—Total, four to six weeks; partial, two to four weeks.

Nose Fracture

This description includes that of the two *nasal bones* proper; the *septum*, *cartilages*, and the *nasal process* of the *superior maxillary*, and *frontal* (perpendicular plate), *vomer*, and *lacrimals*.

Anatomy and Landmarks.—*Nasal bones* triangular, and located at the upper and lateral fixed portions of the nostrils (Fig. 241).

Septum the dividing cartilaginous partition, with a more or less marked normal lateral deviation, almost always.

Cartilages.—The *quadrilateral* join the nasal and ethmoid bones above, the vomer behind, and the lower lateral cartilage at the tip (Fig. 242).

Causes and Sites.—*Direct violence* practically the sole origin, as from blows, kicks, or falls.

Indirect Violence.—A rare source in connection with other injuries. Very frequently the fracture is compound (open) because of wounds in the skin or nasal mucous membrane.

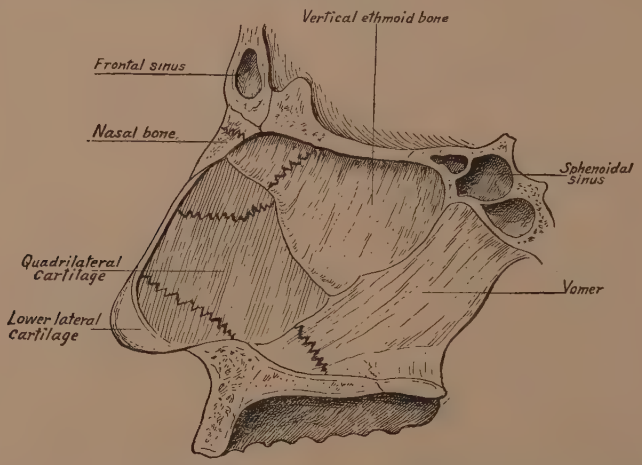


Fig. 241.—Bony and cartilaginous structures of and about the nose. Black wavy lines indicate usual fracture sites.

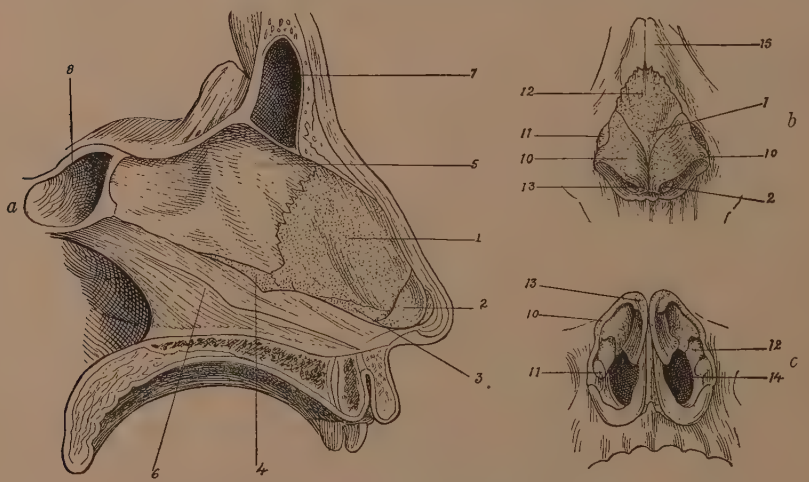


Fig. 242.—Anatomy of the nose.

a, Lateral view, nasal septum: 1, Septal cartilage; 2, lower lateral cartilage; 3, vomer cartilage; 4, sphenoidal process; 5, ethmoid (perpendicular plate); 6, vomer; 7, frontal sinus; 8, sphenoidal sinus. *b*, Nasal bone and cartilage, front view: 12, Upper lateral cartilage; 11, small alar cartilage; 10, lower lateral cartilage; 13, tip of cartilage; 16, nasal bone; 1, septal cartilage; 2, lower lateral cartilage (mesial crus). *c*, Nasal cartilages from below: 13, Tip of cartilage; 10, lower lateral cartilage; 11, small alar cartilage; 14, nasal opening; 12, lower lateral cartilage.

Nasal bones alone may be broken, especially at the lower part where the cartilage joins, and hence the latter are frequently involved at the same time.

Septum cartilages may be broken or separated at their (*a*) nasal attachments; (*b*) from the superior maxilla; (*c*) from the inferior cartilage at the tip.

Lines of fracture may so radiate as to involve small portions of the frontal, superior maxillary, lacrimal, ethmoid, and vomer bones.

The commonest form is a combination of one broken nasal bone with some separation of an attached cartilage, thus deviating the septum.

Symptoms.—*Deformity* is common from swollen soft parts and a tilted or flattened "bridge." *Bloody nose. Ecchymosis of eyelids.*

Fig. 243.—Fracture of the nose.

Occasionally local *emphysema* occurs from the frontal sinus, especially if nose blowing is done. *Plugged nostril*, causing difficult breathing. *Lacrimal duct* plugging rare; when it occurs tears flow over face (epiphora).

Hematoma septum usually seen later; may occur without fracture. *Crepitus, motility,* and *pain* on manipulation; finger or instrument in nose may verify these foregoing (Fig. 243).

Via speculum the distorted swollen septum is best apparent; this is the most reliable means of determining the exact extent of injury. When seen after a few hours, the swelling and pain may prevent any accurate opinion.

Treatment.—*Reduction* cannot be properly made in many cases without some anesthesia, local or general; this is especially so in cases seen after twenty-four hours.

In cases with great swelling or bleeding, cold applications and preliminary gauze plugging may well be the primary measures. Speaking generally, immediate reduction is indicated.

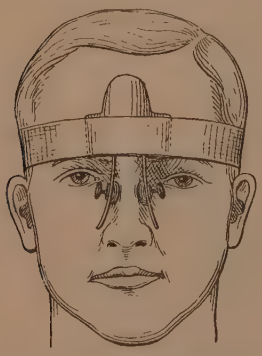


Fig. 244.—Metal splint for fracture of the nose.

After a week it will be impossible to adjust the fragments on account of firm union. A speculum and intranasal light are very helpful. Setting once properly made usually persists.

Manipulation, bidigital or instrumental, to restore the fragments is usually necessary, and this should be done promptly except where epistaxis or great swelling prevents. A blunt conical bullet probe, urinary sound, artery clamp, or similar instrument can be used where the finger is inefficient for elevation or other procedures. High fractures need a flat instrument like a periosteal elevator.

Immobilization is well maintained by perforated metal or hard rubber *Asch splints*, formerly used in septum deviation operations; one on each side of the same size should be used.

Adhesive plaster strapped over the pressed upon bridge is effective only if minor displacement exists.

Rubber tubing (wrapped in gauze) or *gauze packing* of iodoform carefully introduced on the injured side is most valuable in the lower septum injuries. *Special splints*, fastened by head-bands with lateral prongs to press upon the nostrils, are usually needed in fractures high up or those tending toward redisplacement (Fig. 244). Of these, the Cobb and Coolidge may be recommended. *Wounds* are treated like those elsewhere.

Whatever method is used, much attention is given to keeping the *nostrils clean* by antiseptic irrigations, the head being held forward while they are being introduced to prevent sinus extension. The patient is to be cautioned against efforts similar to those of blowing the nose or snuffing up.

Union is complete in two to three weeks and splintage is rarely needed beyond a fortnight.

Complications.—*Erysipelas* and *cellulitis* are not uncommon, especially in neglected, compound (open), and assault cases.

Chondritis and *perichondritis* and *periostitis* occur occasionally, especially in badly contused and infected cases; permanent thickening usually ensues from these.

Abscess of septum with subsequent deformity is most likely where repeated intranasal examination is neglected; pain, swelling, occlusion, and discharge are the usual signs.

Hematoma of septum is rare with fracture and common without it; if present and irreducible by pressure, it should be incised to prevent abscess.

Necrosis is sequential to the foregoing; a rare sequel.

Epistaxis occasionally is recurrent, but prompt and proper treatment is generally preventive; it is commonest in alcoholic, cardiovascular, and anemic patients (Fig. 245).

Fig. 245.—Epistaxis controlled by water or air inflation of a rubber finger-cot, condom, or glove-finger.

Results.—Deformity to some extent is exceedingly common, and for that reason a perfect restoration of profile should be guardedly promised; the common remnants are tilting or depression. Some of these are capable of plastic correction. Deviation of the septum can be marked without serious inconvenience.

Disability.—Total, two to four weeks; partial, one to three weeks.

Malar Fracture

This occurs rarely as an isolated lesion, but may be an associate of extensive adjacent injuries.

Causes.—*Direct violence* always, as by a severe blow, fall, or kick.

Symptoms.—*Deformity* of the much swollen cheek and orbit usually obscures the bony signs. Epistaxis and ecchymosis of the lids are common. Crepitus and mobility are rare. *Local pain* and a *depression* are the usual signs, and these are best elicited by standing behind the patient and passing the index and middle fingers outward

from each nasolabial fold toward the ear orifice. This maneuver palpates the *zygoma* and *body* of bone, the parts usually involved.

Anesthesia or *paresthesia* of parts of the cheek, gums, or upper teeth may exist if the infra-orbital nerve is involved. *Motion* of the lower jaw may be diminished.

Treatment.—*Reduction.*—In the ordinary case this cannot be done without operation to expose the fracture through the cheek or mouth, and then traction by a hook or other device is employed. In involvement of the *zygoma* alone, pressure is usually effectively applied outside and inside the cheek. Once reduced, the position tends to remain without any dressing; adhesive straps over gauze pads may sometimes prove helpful.

Results.—Deformity may persist as a dimpling, depression, knobbing, or sagging. Impaired motions of the jaw are usually regained.

Disability.—Total, two to six weeks; partial, one to three weeks.

Fracture of the Clavicle

This is exceedingly common, and of all fractures of single bones ranks third or fourth in frequency. It occurs often in children from the sort of violence which in later life dislocates the shoulder.

In my series there were 236 cases, $4\frac{1}{2}$ percentage of all.

Anatomy and Landmarks.—This **S**-shaped bone is about 6 inches long and divided into thirds, and it is visible and palpable practically throughout.

Inner or Sternal End.—Knobbed and has some motion.

Outer or Acromial End.—Flat and also somewhat motile.

Tubercle or Knob.—On upper part of outer third; this may be misleading in some atypical fractures.

Causes.—*Direct Violence.*—Rare, as from a blow or fall or other localized impact; breakage from this source is usually located about the middle or outer third, and then generally it is compound (open).

Indirect Violence.—Usual origin, as by a fall on the shoulder, elbow, or hand, the extremity being rigid.

Muscular Violence.—Exceptionally causative, as by lifting, swinging, or contracting motions.

Varieties.—Usually the cleavage is *oblique*, *complete* and *simple*, and about one-half of all varieties are in the middle third, approximately within 2 or 3 inches of the outer end. About one-third of the remainder are at the junction of the middle and outer thirds.

Greenstick or Bending.—These occur in children only.

Partial.—A rare form in which a border or edge is split, or the bone is not broken completely across.

Multiple and Comminuted.—Very rare forms.

Symptoms.—*Deformity* of attitude, so that the drooping shoulder is lifted up and supported by the opposite hand; visible irregularity in outline of the bone; swelling and ecchymosis later appear.

Crepitus, false motion, irregularity, and local pain are confirmatory signs.

In cases showing little displacement, *local pain* elicited by direct "point" or finger pressure, or that produced by pushing against the

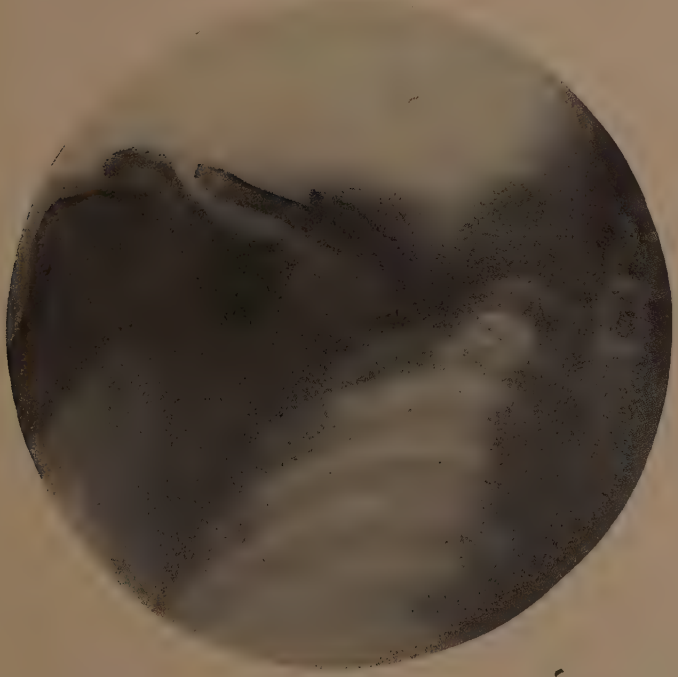


Fig. 246.—Fracture of middle of clavicle (comminuted). Treatment indicated: Sayre's adhesive dressing or plaster-of-Paris shoulder spica with arm in abduction.

bone from within out, will sometimes verify suspicions. In typical cases the outer fragment is usually found drawn *down* and *in;* the inner, drawn *up* and *out* by muscular contraction.

Adult fractures often show much obliquity and impaction (Figs. 246–248). In the young the fracture line is generally transverse or nearly so (Fig. 249).

Treatment.—The shoulder is dropped *down and in*, and the object is to push it *up and out.*

Fig. 247.—Fracture of the clavicle (outer third).

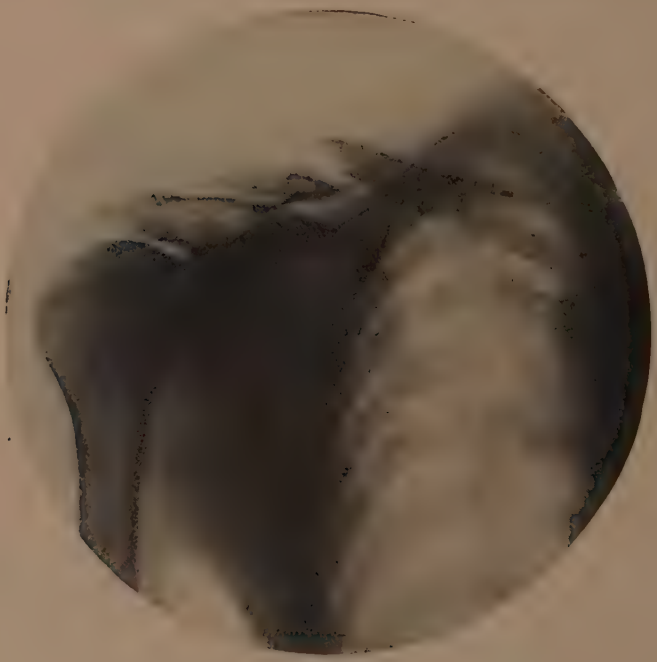


Fig. 248.—Fracture of the clavicle (outer third).

Reduction is thus accomplished by raising the shoulder and pulling it backward. This occurs sometimes spontaneously if the patient is

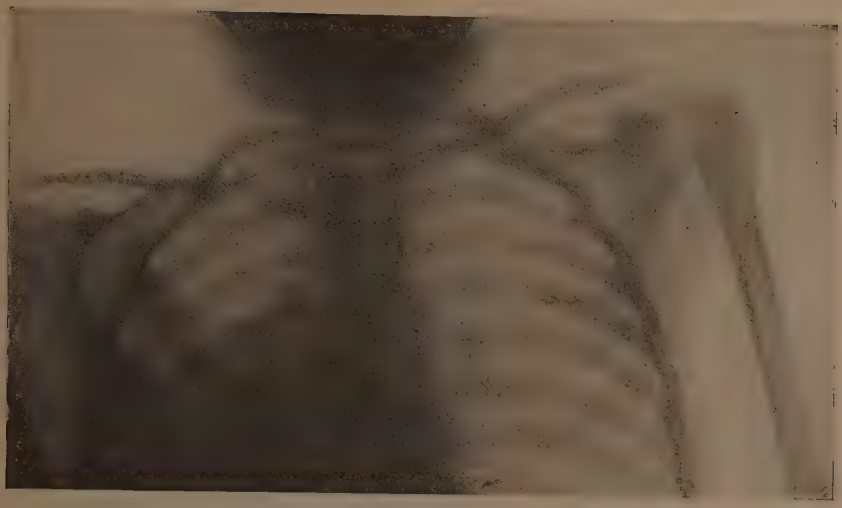


Fig. 249.—Fracture of the clavicle (outer third) in a child.

Fig. 250.

Fig. 251.

Sayre's adhesive plaster dressing for fractured clavicle. Fig. 250, posterior piece to *retract* shoulder. Fig, 251, anterior piece to *elevate* shoulder. Note the padding in the axilla and under the palm; the olecranon pressure is relieved by an opening in the plaster.

placed on the back with a pillow between the shoulder-blades. Standing behind the patient and placing the knee between the shoulders and forcing them backward is also useful. With the patient seated on a

stool, abducting both arms to a right angle, and pulling the scapulæ toward each other is also an aid to setting (Fig. 253).

With much overlapping or impaction, anesthesia or operation may be necessary to overcome the deformity. Occasionally osteotomy alone is efficient.

Immobilization is difficult, but is best maintained in the average case by the *Sayre dressing* of zinc oxid adhesive plaster applied as shown in Figs. 250, 251. Mayor's scarf sling may also be used (Fig. 252). Axillary vessel freedom is assured if space enough is left to insert two fingers at the inner edge of the arm-piece of the adhesive. A gauze bandage shoulder-cap may well be used with this for a time. In very fat people and in women the above dressing sometimes cannot be used; in these, a shoulder bandage will answer usually. Whatever method is used, preliminary removal of hair is advisable. The parts should be well dried and the axilla dusted with talcum or other powder.

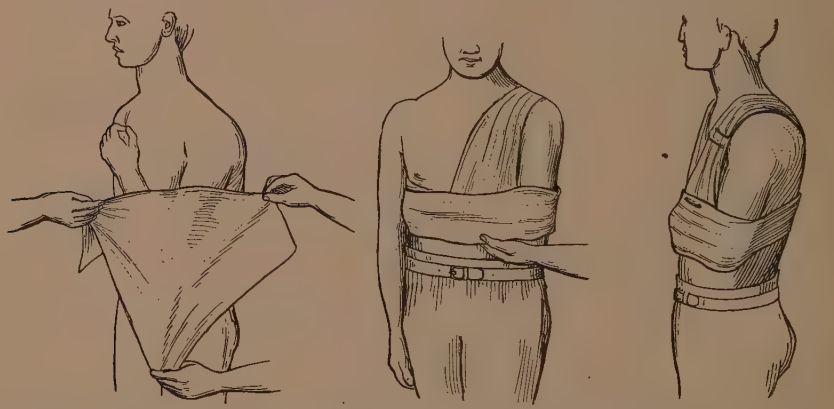


Fig. 252.—Mayor's scarf sling for fracture of the clavicle or other injuries of the shoulder girdle.

In women, or in those who seek a cosmetic rather than a functional recovery, it may be advisable to reinforce the foregoing by insisting upon a dorsal position with a pillow between the shoulders for a week or ten days. Couteaud's posture treatment is allied to this (Fig. 254).

Apparatus specially designed of wood or metal is rarely employed.

Operation and direct coaptation by sutures (gut or wire) or plating is reserved for great deformity, compounded, or ancient untreated cases. The dressings are worn for two or three weeks by children; in adults, two to four weeks.

The author advocates the use of his plaster-of-Paris "abduction method" in certain cases not well retained by the usual dressings[1]

[1] Published in *The Post Graduate*, Dec., 1914.

Fig. 253.—Postural reduction of fracture of the clavicle by (*a*) abduction and (*b*) retraction of the arms and shoulders.

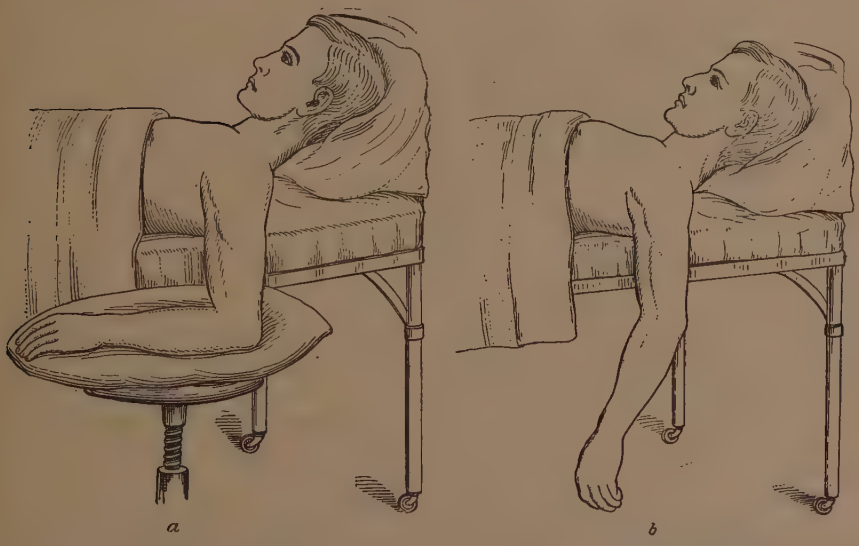


Fig. 254.—Couteaud's position in fracture of the clavicle: *a*, Shoulder slightly elevated; *b*, shoulder depressed.

(Fig. 253; see also Fig. 281). Couteaud advocates the positions indicated in Fig. 254, this prone posture being maintained for two weeks.

Results.— *Union* is complete by the end of three weeks (Fig. 255). *Deformity* is shown by marked early irregularity or callus, but it usually disappears wholly and is always lessened in time; but the site of fracture is practically never free of some irregularity even after a lapse of years. Despite marked deformity, with or without bony union, the rule is for complete recovery; here, as in many other fractures, *deformity* by no means implies *disability*.

Fibrous Union.—Not uncommon, and frequently it causes no loss of function.

Fig. 255.—Fracture of the clavicle (left outer third). Note accurate reduction obtained by abduction and elevation of arm and retention by plaster-of-Paris shoulder spica.

Impaired Motion and Ankylosis.—Shoulder stiffness for a time is not unusual; if immobilized by treatment longer than a month the amount and duration of stiffness is generally due to the treatment more than the fracture. Massage and forced use eventually bring about restoration even in marked cases.

Atrophy is commensurate with the above.

Nerves.—Those in the axilla are rarely affected; *circumflex* and *spinal accessory* occasionally are involved, but recovery in all forms is the rule.

Disability.—Total, four to six weeks; partial, two to six weeks.

Scapula Fracture

This is rather rare and does not constitute more than 1 per cent. of all.

Anatomy and Landmarks.—*Body.*—Palpable over the lower portion.

Vertebral Border.—Brought best to view by elevation and abduction.

Spine.—Visible and palpable, wholly or in part.

Processes: acromion, at outer end of spine and jointed to the clavicle; *coracoid*, overhanging the axilla.

Glenoid Cavity.—Rim sometimes palpable (Fig. 256).

Causes.—*Direct Violence.*—Blows or falls, especially common in fractures of the *body* and *acromion*.

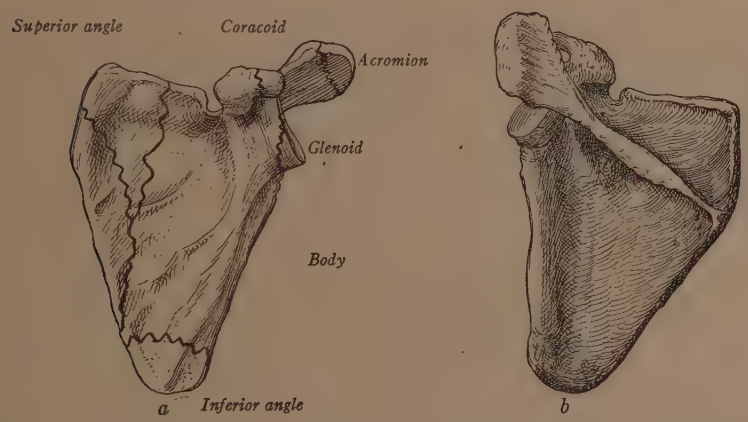


Fig. 256.—*a*, Common sites of fracture of the scapula; *b*, normal scapula, posterior view.

Indirect Violence.—Blows or falls on the shoulder or elbow; not infrequently an associate of humerus injuries.

Muscular Violence.—Rare, except as affecting the processes.

Varieties and Sites.—Commonest in the *body*, *spine*, *acromion*, and *coracoid;* rare in the *glenoid* and *neck*. Fracture lines may be single or multiple in the *body* varieties.

Symptoms.—*Body.*—Deformity and disability about the shoulder varies; the commonest signs are crepitus, false motion, and pain on pressure against the ribs or when the arm is abducted. Ecchymosis and swelling may occur.

Spine.—Deformity and disability variable; commonly crepitus, false motion, and local pain are determinative.

Acromion and Coracoid.—Deformity slight, if any. Ecchymosis

and local swelling variable. Crepitus, false motion, and local pain exist; abduction or elevation of the arm best elicit the foregoing signs.

In all, *x*-ray corroborations may be necessary.

Treatment.—*Body and Spine.*—Reduction is by manipulation of the fragments or arm, or both, and maintenance of same in the corrected position by binding the elevated arm to the side with a shoulder-cap bandage, adhesive plaster (Sayre's dressing or modifications), or plaster of Paris.

Acromion and Coracoid.—Reduction, and application of Sayre's dressing or modification, with direct pressure by gauze or cotton pads; or bandages to relax the muscle pull and keep the shoulder at rest.

Results.—*Body* and *spine:* Union occurs with more or less callus in four or five weeks and complete restoration is general; some pain may for a time persist on elevation of the arm, deep breathing, or actions bringing the ribs and the body of the bone in contact.

Processes.—Bony union generally does not occur (except in impacted forms) and the length of the fibrous uniting bands may widely separate the fragments without marked loss of function. Healing is generally complete in three or four weeks.

Disability.—Body and *spine:* Total, four to six weeks; partial, one to three weeks. *Processes:* Total, three to five weeks; partial, one to two weeks.

Sternum Fracture

A rare injury unless associated with fractured ribs or fatal chest crushes (Fig. 257).

Anatomy and Landmarks.—*Manubrium:* The intersternal notch and junction for clavicle and first ribs are palpable and sometimes visible. *Gladiolus:* Only anterior portion palpable usually. *Ensiform* (*xiphoid*) *appendix:* Variable in shape, position, and motility.

Up to the age of twenty-five each of the foregoing are made up of several segments. The ensiform joins the gladiolus about the fortieth year; partial bony junction may rarely unite the manubrium and gladiolus late in life, but usually they remain separated. The foregoing is the reason for freedom from fracture before the twenty-fifth year, dislocation consequently being more common.

Causes.—*Direct Violence.*—Commonest, as from blows, missiles, falling or moving objects, or crushes.

Indirect Violence.—A rare and improbable source.

Muscular Violence.—Occasional, as from great straining or exertion.

Sites and Varieties.—Usually breakage occurs at the junction of the first and second segment, involving the lowest end of the manubrium; next commonest location is about the center of the gladiolus. Simple, transverse, more or less complete forms are usual; compound or multiple forms are rare in those recovering. Dislocation may be hard to exclude in some instances.

Symptoms.—Dyspnea, cyanosis, cough, and hemoptysis common. *Palpation* elicits irregularity, local pain, and perhaps crepitus and false motion. In a severe case there will be a good deal of shock or prostration.

Treatment.—*Reduction* by direct pressure, or manipulating the arms and chest may be enough. Sometimes it may best be made by bracing

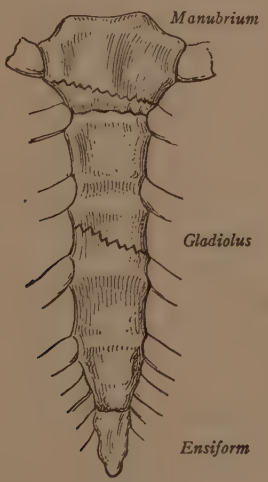


Fig. 257.—Lines of fracture of the sternum.

the patient's back against the edge of a box, or a dorsal posture over the edge of the table may be assumed, so that the shoulders and upper chest will fall backward, pressure over the line of breakage then being added. Respiratory efforts and coughing sometimes lend additional help. *Operative aid* is rarely needed. *Immobilization* is by a wide strap or straps of adhesive completely encircling the chest, applied during expiration.

Results.—If *shock* is survived and pneumonia or local *necrosis* does not complicate, healing is complete in from five to eight weeks. Deformity may persist permanently, but generally this causes no trouble; in appearance it may resemble the "rickety chest."

Disability.—Total, five to eight weeks; partial, two to four weeks.

Rib Fracture

These are exceedingly common and in my list of cases ranked second in frequency, a percentage of 11.7.

Anatomy and Landmarks.—Of the twelve, seven are attached to the sternum, forming the so-called *true ribs;* of the five remaining *false ribs,* the eighth, ninth, and tenth are attached in front by cartilage, the eleventh and twelfth, being unattached in front (floating ribs), are very movable and thus rarely broken. The first and second are fairly well overlapped by the clavicle and usually escape injury; those forming the widest part of the barrel-shaped thorax are most

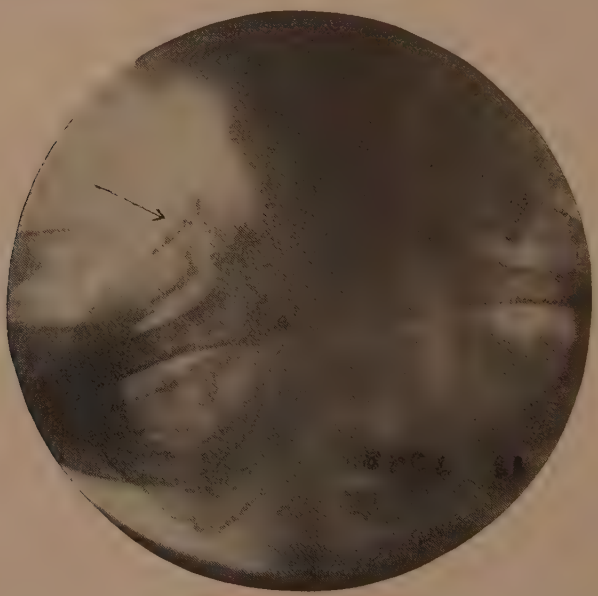


Fig. 258.—Fracture of the first rib at its anterior attachment; a very rare injury.

exposed to violence, and thus the fifth, sixth, and seventh are oftenest broken (Fig. 258). Ribs do not completely ossify until the twenty-fifth year, and they are quite elastic in children, thus accounting for the great rarity of fractured ribs in the young.

Most ribs are palpable throughout and many of them are also visible. The intercostal and other muscles and ligaments are so strongly interlaced and intimately attached that great displacement of fragments is rare (Fig. 259).

Causes.—*Direct Violence:* Common, notably a localized blow or fall on a projecting surface, or contact with a raised edge of a moving or stationary object. *Indirect violence:* Rather more frequent, as in

accidents tending to narrow the anteroposterior diameter of the chest, thus causing a bulging at the lateral margins and fracture at a distance from the source of pressure; this is often aptly illustrated by forcing together the ends of a barrel hoop and noting that the break is at the center or nearly so—a sort of "bursting" fracture. Crushing and jamming accidents are common causes. *Muscular violence:* Occasionally a source, as during violent sneezing, coughing, or powerful lifting or straining actions; if broken in this manner, the lowest ribs are generally involved, and it occurs from this source more often on the left side of the chest.

Sites and Varieties.—Commonly breakage occurs a few inches outside the sternal attachment; that is, at or near the line of the nipple,

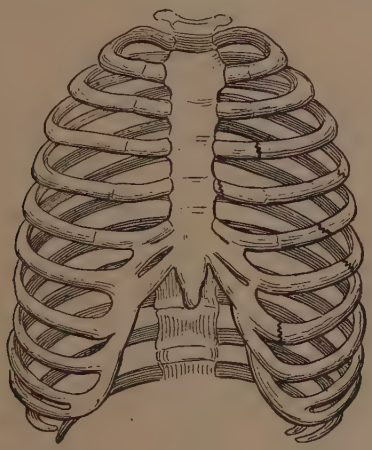


Fig. 259.—Lines of fracture of the ribs.

and this is especially so if the source is direct injury. If caused by an indirect or squeezing force, they may be broken further back and on either or both sides.

Complete and *incomplete fractures* occur, the latter as indentings without much change of contour or definite signs. *Multiple fracture* is not uncommon, adjacent ribs being usually affected (Fig. 260). *Compound* or *comminuted types* are rare and usually result from bullet wounds or severe crushing accidents (Fig. 261).

Fracture at the attached ends (sternal or vertebral) is very uncommon.

Symptoms.—*Focal Signs.*—Visible swelling, ecchymosis, and changed contour sometimes. *Local pain* on direct pressure, or that elicited by forcing the sternum backward may be the main sign; this

sign is also brought out and localized in the same area by forced inspiration, coughing, or effort. False motion and irregularity are rather rare. Crepitus (tactile or auscultatory) may be from the bone, emphysema, blood, soft parts, pleura, or lung; hence it is an unreliable sign.

General Signs.—Breathing is usually characteristically affected (dyspnea), and it becomes shallow, quick, jerky, or cog-wheel, and usually an upright position is chosen to relieve respiratory involvement; but if a prone position is chosen, the injured side will be kept at rest

Fig. 260.—Multiple fractures of the ribs at the arrow marks.

by contact with whatever the patient is resting upon. *Speech* is likely to partake of the respiratory difficulty, and it is limited and likely to be jerkily whispered or quickly sputtered, all in an effort to limit inspiration. *Cyanosis* and *cough* are frequent. *Bloody expectoration* may occur, but it does not of itself indicate gravity or extensive lung damage; it is often absent in serious and present in ordinary cases. *Emphysema* localized about the fracture or even spreading over the chest, face, and abdomen is not very infrequent; it indicates a punctured pleura and is not usually a serious feature, as it disappears

during the course of treatment. *Pneumothorax* or *hemothorax* (singly or together) also occurs occasionally, the former more commonly; it indicates that the pleural cavity or lung has been entered.

Summation of Signs.—The average patient will be *short of breath* and have a jerky cough and point to a small *painful area* of the chest (usually this is not larger than a half-dollar), and this region will be *tender* when pressed upon or when strain is brought on it by squeezing or "springing" the chest wall; there may be *crepitus* here or localized *pleurisy* signs; the outline of the ribs may be changed and there may be some bloody, frothy spittle.

Fig. 261.—Compound fracture of the sixth and seventh ribs in a child due to automobile accident.

Treatment.—*Reduction* is usually not needed, but if it is, pressure and manipulation may produce it, but operative replacement is only necessary if urgent impingement exists. *Immobilization* is provided by adhesive plaster strapping applied around the chest during expiration; in whatever way applied, it should tightly include more than half the chest to be of any value. In applying it the arms should *not* be elevated, as that position of itself expands the chest. It is first fastened behind just beyond the midspine and brought taut toward the injured side with a rapid swing to beyond the center of the chest or further; it wants to be snug, but not painful. If small **V**-shaped sections are cut from its upper margins considerable space will be

gained and perhaps make complete removal unnecessary in the event of too great pressure. The adhesive need not contact throughout

Fig. 262.—Strapping chest (front view).

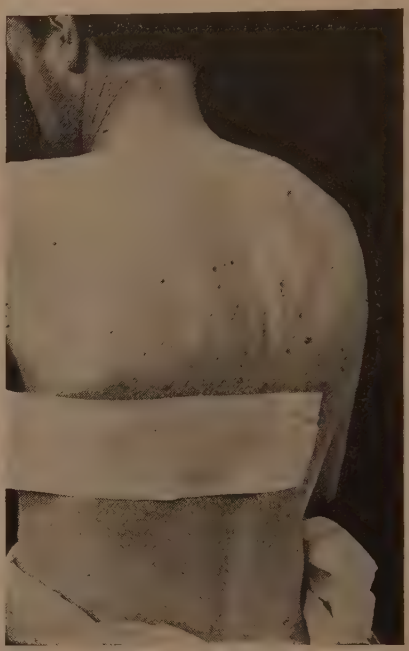


Fig. 263.—Strapping chest (back view).

with the skin, as it often unduly irritates; gauze laid along the strap as shown in Fig. 264 makes the strapping quite as efficient and much more comfortable.

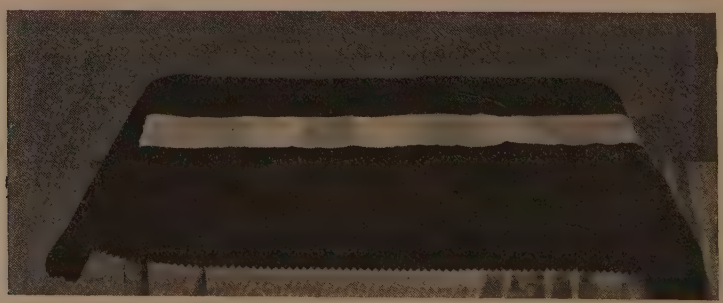
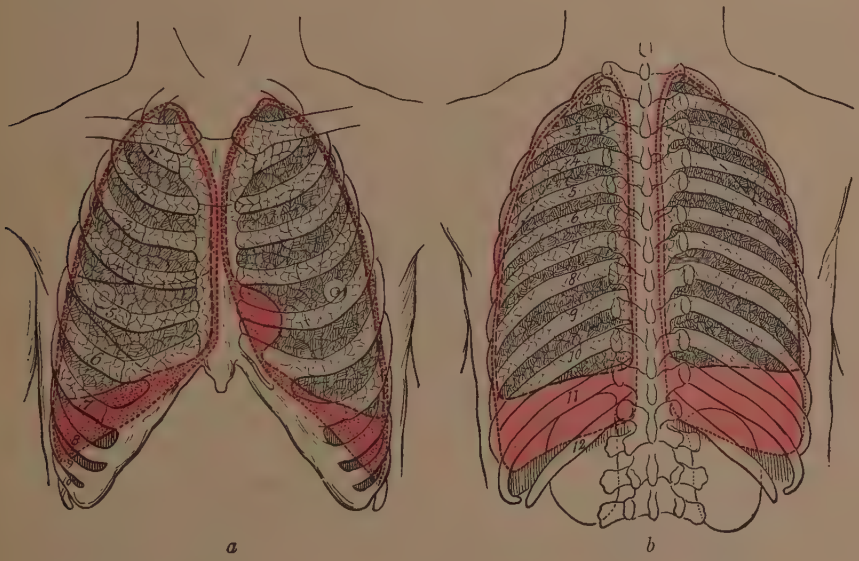


Fig. 264.—Single layer of gauze to protect skin when large amounts of adhesive plaster are applied.

Dressings.—(1) *Broad Strapping.*—A 4- to 8-inch wide strip of zinc oxid adhesive is applied to the shaved chest.

(2) *Narrow Strapping.*—3-inch overlapping strips are applied, beginning above and covering an area several inches above and below the fracture.

(3) *Malgaigne's Dressing.*—For a left-sided injury, a 3-inch strap is started from the *right* front end of the seventh rib, and passes to the left across the chest and under the *left* arm, and across the back and over the *right* shoulder; thence again across the front of the chest and around the *left* side and back, to end at the *right* iliac crest. This leaves the *right* side free; it can be reversed for injury to the opposite chest. The arms, if bound to the side, aid this form of immobilization.



a *b*

Fig. 265.—Relation of pleura (red) to chest wall: *a*, Anterior extent; *b*, posterior extent.

Plaster is worn three weeks, and its removal is facilitated by hot water, gasolene, ether, wintergreen, or camphorated oil. The remaining plentiful crop of itchy pimples are benefited by alcohol and dusting-powders; such acne-like signs are fair indications that some sort of plaster was recently used. A flannel or muslin bandage sometimes is desired for a week or two longer. Plaster of Paris, starch, and other bandages cannot be applied firmly enough to be of supportive value.

Complications.—*Pleurisy*, localized to the fracture site, is quite common. It practically never becomes serous or purulent and generally disappears before the fracture is finally knit (Fig. 265).

Pneumonia.—Rare; it begins within the first three days and is generally lobar in type. The *hypostatic form* seems no more common as

a late manifestation of this than of other fractures; and the aged and alcoholic are rather prone to have it develop in this and many other injuries.

Hemorrhage from the intercostal arteries or torn lung is rarely prominent; exceptionally it requires removal by aspiration.

Intercostal neuralgia occasionally occurs; no special treatment is needed. It may last for some weeks after union occurs, but is never permanent.

Traumatic asphyxia (also called "the ecchymotic mask") is an accompaniment of severe crushes of the chest and usually is due to jamming between moving objects, as in coupling cars or squeezes between a moving and stationary object. In addition to broken ribs and dislocated cartilages, there is great dyspnea and cyanosis, with ecchymoses and subconjunctival hemorrhages. It is said also to occur from impingement of the abdomen.

The one patient I have seen was rolled at the upper chest level between the projecting edges of two trolley cars, and from his neck to

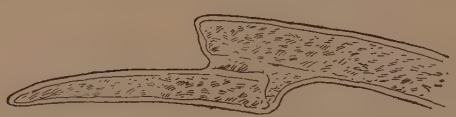


Fig. 266.—Callous formation in overlapping fracture of a rib.

the top of his forehead he was dusky blue, his eyes protruded, and the conjunctivæ were deeply hemorrhagic. The unconsciousness lasted several hours and there were numerous ecchymoses and petechial hemorrhages on the upper chest and several broken ribs. A diagnosis of fractured base of the skull was made before the exact mechanism of the accident was explained. He recovered despite a marked old endocarditis. Most cases get well.

Strangulation sometimes causes similar facial and neck appearances.

Results.—Complete and rapid recovery is the rule from rib fractures. Callous formation is complete by the end of the third week; it may be quite marked at first, but usually smooths away (Fig. 266). Pleuritic adhesions occasionally result and may give pain until gradual stretching releases them. Pulmonary remnants are exceedingly rare.

Disability Period.—Total, two to four weeks; partial, one to three weeks.

Costal Cartilage Fracture

This is exceedingly rare and rather difficult to differentiate from dislocation. Less than 100 cases have been recorded.

Causes.—Direct falls and blows.

Sites and Varieties.—At the junction with the rib (costochondral), usually involving the seventh or eighth rib. It is generally *simple* and *complete*, with some displacement.

Symptoms and Treatment.—Similar to fractured ribs.

Humerus Fractures

This bone is rather uncommonly broken, forming 3 to 6 per cent. of all fractures.

Fig. 267.—Relation of nerves to head of humerus.

Anatomy and Landmarks.—*Upper End.*—*Head* can be felt to rotate in the glenoid, especially on deep axillary pressure (Figs. 267,

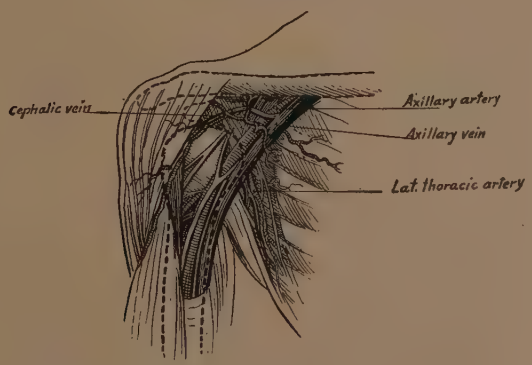


Fig. 268.—Relation of blood-vessels to head of humerus.

268). *Greater tuberosity* forms the bony point or prominence at the shoulder and projects beyond the acromion process; sometimes pal-

pable. *Shaft*, palpable to some extent, especially in the central part (Fig. 269).

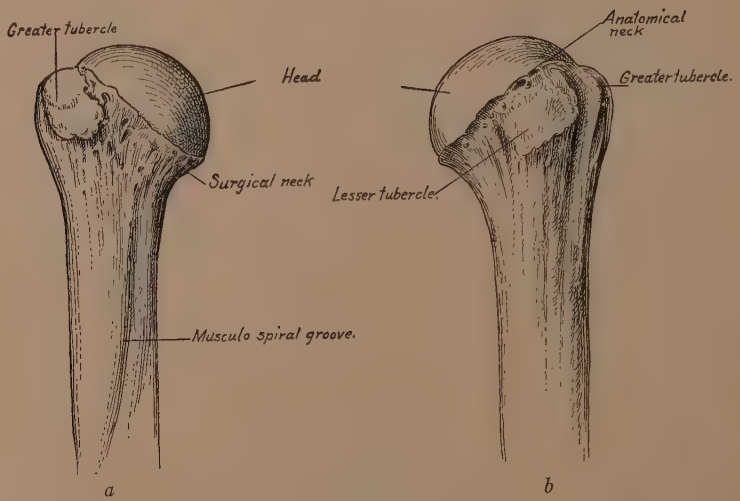


Fig. 269.—Upper end of humerus: *a*, anterior view; *b*, posterior view.

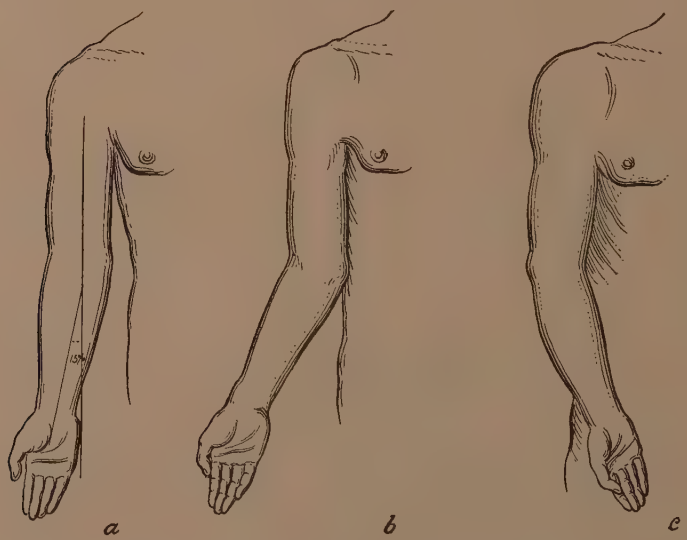


Fig. 270.—Carrying angle of arm: *a*, Normal, 15° from a straight line, about 165°; *b*, cubitus varus or gunstock deformity; *c*, cubitus valgus.

Lower End.—Internal condyle prominently visible and palpable. *External condyle* less marked than the above, and leading up from it is the *condyloid ridge.*

Sites and Varieties.— *Upper End:* Head, anatomic neck, surgical neck, tuberosities, and epiphysis. *Shaft, lower end:* Internal condyle, external condyle, epiphysis, combinations.

Head.—This is broken so rarely as to be a curiosity.

Anatomic Neck.—This corresponds in great measure to the intracapsular fracture of the neck of the femur. Relatively it is a very rare sort of injury and generally occurs in old people, and is usually impacted or combined with dislocation or fracture of a tuberosity.

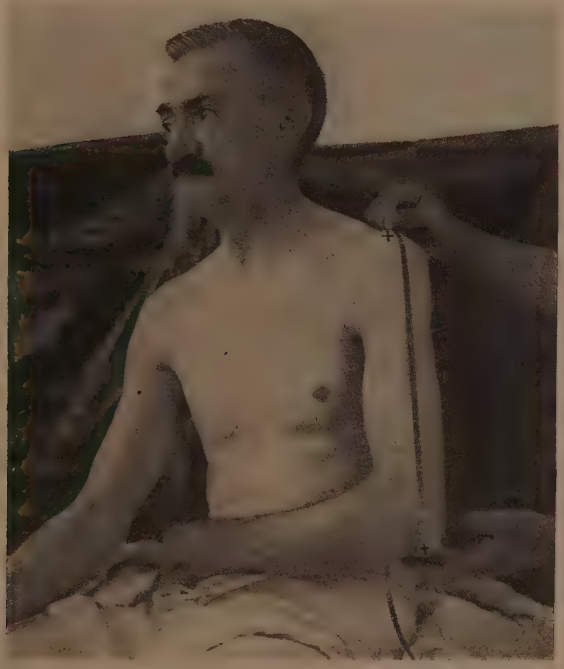


Fig. 271.—Landmarks for measurements of the arm. Tip of the acromion and olecranon processes (black cross) and internal condyle (white mark on tape).

Causes.—Direct falls on the shoulder is the common source; less often indirect violence transmitted from falls on the elbow or hand is at fault.

Diagnosis.—The joint is disabled, painful, and swollen; there may be slight deltoid flattening; crepitus is variable; pain on pressure and motion exist; shortening is slight if present at all. Ecchymosis occurs later; *x*-ray examination is often needed for confirmation and differentiation (Fig. 271).

Treatment.—*Impacted* or non-displacement forms need practically nothing beyond a bandage and sling to keep the arm at the side for three or four weeks.

Unimpacted or displacement forms may sometimes be helped by traction and abduction, with the arm later fixed at the side of chest with a pad in the axilla. Others do better with the arm held in right-angled abduction, as indicated below. *Operation* may be needed where dislocation is associated, and then the fragment is sometimes removed if replacement cannot be otherwise accomplished. Occasionally nailing may be necessary; but in old people all operative procedures must be limited to selected cases.

Results.—Union occurs in three or four weeks if at all; the impacted cases do better than the others, but in all there may be some permanent shoulder disability.

TUBEROSITIES

These are rarely broken alone, but usually are accompaniments of anatomic neck fracture, or dislocation of the shoulder. The lesser tuberosity is rarely involved.

Causes.—Generally a direct fall or blow on the shoulder, or less often a severe muscular contraction or abduction is at fault.

Diagnosis is made by exclusion plus the finding in the swollen, tender joint such signs as local pain and perhaps crepitus on manipulation, notably during abduction; *x*-ray confirmation generally is necessary.

Treatment.—*Reduction* usually is not needed; if much displacement is present, open operation and fixation by suture or pinning is sometimes required. *Immobilization*, as made in anatomic neck fracture, usually suffices.

Results.—Deformity is very unlikely and disability is slight, if any occurs; complicating injuries modify this outcome. Fibrous union is common and does not interfere with function.

Disability.—Total, four to six weeks; partial, two to four weeks.

EPIPHYSIS

This is *the* injury about the shoulder in children. It never occurs after the twentieth, and is relatively commonest from the ninth to seventeenth year. This is the most frequent of all epiphyseal separations.

Causes.—Blows, falls, and pulls *on* the joint are the ordinary sources; occasionally the same factors act from a distance, but indirect is far less productive than direct violence.

Symptoms.—The arm is disabled and the deformity looks not unlike that of an adult dislocation of the shoulder; there is distortion

and swelling of the shoulder and the axillary fold level is altered. Palpation discloses the head in place and the upper end of the shaft displaced forward and inward usually. Local pain, some false motion and a soft crepitus may exist. If there is little or no displacement, *x*-ray confirmation or anesthesia will be needed for accurate diagnosis.

Treatment.—*Reduction* may be exceedingly difficult to maintain without *operation*. Setting is best accomplished by traction and abduction, this being maintained by a triangular pad in the axilla and a shoulder-cap and cast, after the manner of some shaft fractures. Some with little displacement do well enough by simply keeping the arm at the side and using a sling. The position of right-angled abduction is probably best for most cases. *Operation* may be necessary for reduction, and *x*-ray examination should be made often before successful replacement is assumed.

Results.—Functional restoration is proportionate to the success of reduction, and in those cases accurately set a perfect result ensues. In those less well reduced there may be some permanent deformity and inability to fully elevate or rotate the arm; however many of these cases eventually do a great deal better than the early clinical and *x*-ray signs indicate, and for all practical purposes complete function is regained. If there is much maladjustment the subsequent growth of the humerus may be badly impaired.

Disability.—Total, four to six weeks; partial, two to four weeks, but a child need be from school a great deal less time than this.

SURGICAL NECK

This comprises all fractures within the upper fourth of the arm and the epiphyseal line; it is the common fracture of this location in adult life and corresponds to the extracapsular fracture of the neck of the femur.

Causes.—Falls or blows on the shoulder, twists of the arm, or falls on the elbow are the usual sources. Muscular action is a rare factor.

Varieties.—The ordinary form is complete and transverse with variable degrees of displacement; it may be impacted or unimpacted. Dislocation of the shoulder or tuberosity fracture are often associated (Fig. 272).

Symptoms.—The disabled joint is swollen, painful, and held in a position of fixation against the chest, supported by the opposite hand. Ecchymosis may be quite marked and extend to the elbow and over the chest. The head of the bone is in place and the fragments may be

palpable in the axilla. In *impacted* cases, crepitus and failure of the head or tuberosity to rotate, constituting abnormal mobility, are

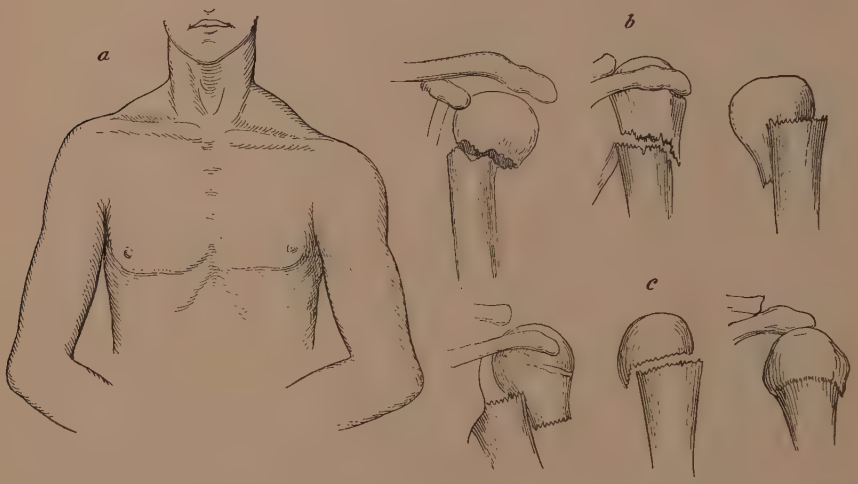


Fig. 272.—Fracture of the surgical neck of the humerus: *a*, External appearance; *b*, *c*, degrees of displacement.

Fig. 273.—Case of R. S., aged sixty-six. Fracture of the surgical neck of the humerus incompletely reduced and held in abduction by a plaster-of-Paris shoulder spica.

determinative signs. Shortening may or may not be demonstrable. Pressure transmitted from the elbow elicits local pain. If much dis-

Fig. 274.—Same as Fig. 273, properly reduced.

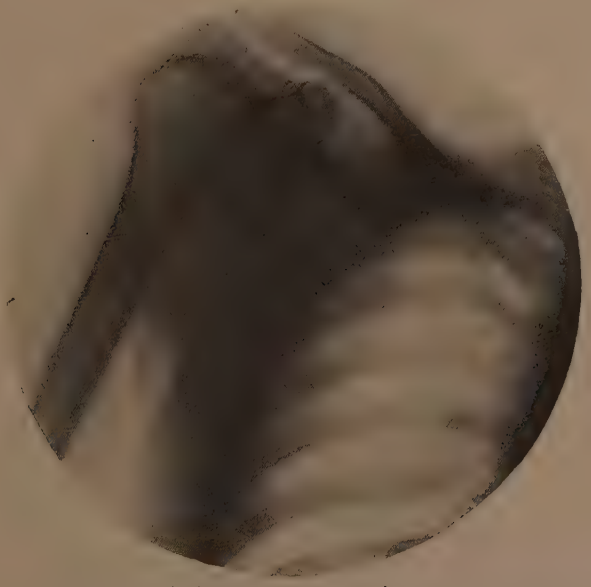


Fig. 275.—Fracture of surgical neck of humerus (impacted). Treatment indicated: axillary pad; arm fastened to chest by a broad swathe of adhesive muslin; sling for forearm; massage on third day; passive motion at end of second week; active motion begun one week later.

placement occurs, the axis of the arm points inward and the level of the axillary fold is changed (Figs. 273–278).

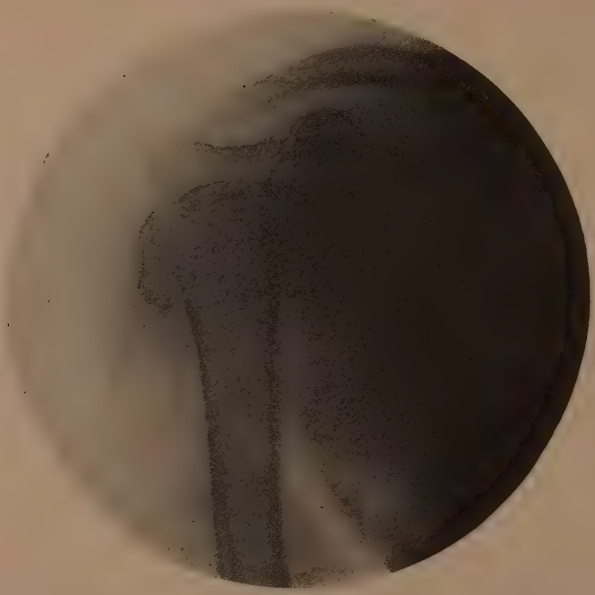


Fig. 276.—Fracture of surgical neck of humerus (impacted).

Fig. 277.—Fracture of the surgical neck of humerus well reduced and held in abduction by plaster-of-Paris shoulder spica.

Treatment.—*Reduction* generally is possible by traction and abduction and some rotation; in some cases anesthesia is needed. In *impacted* cases without much displacement no effort should be made to separate the fragments; in fact, this is the aim of treatment, and once accomplished, redisplacement is unlikely.

Splintage may be by any of the following: (1) Arm *fixed at side* by bandage or adhesive and a sling; this answers for the non-displaced cases (Fig. 279). (2) Arm *abducted* by (*a*) axillary pad (Fig. 280); (*b*) special triangular splints in the axilla like Middledorp's triangle, Monks', or the Osgood-Panhallow's splint; (*c*) plaster-of-Paris splints,

Fig. 278.—Fracture of the surgical neck of the humerus separating the greater tuberosity. Treatment indicated: abduction of arm to right angle and fixation by plaster-of-Paris or other splint in that position.

like Hennequin's or that shown in Fig. 281; (*d*) internal angular splints with weights attached to the elbow (Fig. 282, *d*).

Either of the foregoing will need readjustment as the swelling subsides. None of them should be employed longer than three or four weeks, then being replaced by a sling or adhesive, with or without a removable shoulder-cap, just as soon as union is firm.

My personal preference is for an adhesive strap and sling for the non-displaced cases, and a plaster-of-Paris abduction dressing for the displaced cases (Fig. 281).

Results.—Union is complete in thirty or forty days; non-union is

Fig. 279.—Dressing for non-displaced fracture of the upper part of the humerus, including tuberosities, neck, and adjacent shaft. Note shoulder-cap splint of plaster, felt, or tin, the broad bandage about chest, and a simple sling.

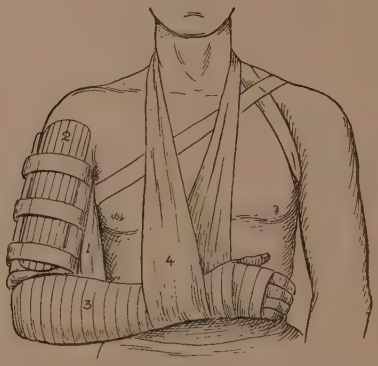


Fig. 280.—Dressing for fracture of the shaft of the humerus, consisting of: 1, padding for the axilla held by a strap passing over the opposite shoulder; 2, padded splints over front and back of arm; 3, gauze bandage from finger to elbow to prevent edema; 4, sling.

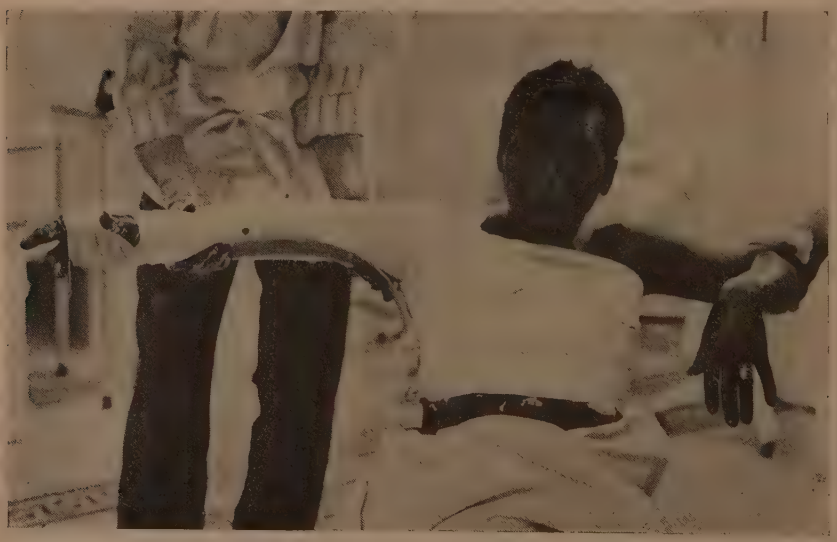


Fig. 281.—Application of an abduction shoulder-splint. Sheet lint or flannel bandages are first applied from fingers along arm and about the injured shoulder as a foundation for plaster-of-Paris spica. Cotton is carefully used to pad the axilla and elbow. A basswood splint helps to support the arm in abduction as here shown.

rather rare. The *impacted cases* usually recover perfectly. The *unimpacted cases* do not do as well and there may be a good deal of stiff-

ness and disability even as long as six months after; but continued use and active attempts to increase abduction, elevation, and rotation of the arm generally brings about an excellent working outcome even in

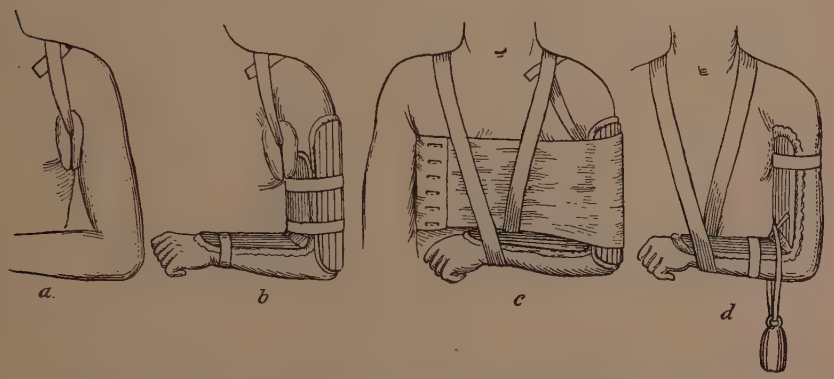


Fig. 282.—Dressing for fracture of the shaft of the humerus, consisting of: *a*, Pad in axilla held by a strap over shoulder; *b*, molded padded plaster-of-Paris, metal, felt, or wood splints applied with forearm pronated; *c*, body swathe (muslin or gauze) and sling; *d*, weight attachment to be used if traction is needed.

seemingly unfavorable cases. In this respect the general outlook is not unlike that of dislocation of the shoulder.

Disability.—Total, five to eight weeks; partial, two to twelve weeks.

SHAFT

This includes the region from below the upper fourth to the supracondyloid ridge.

Causes.—Direct blows or falls sometimes are at fault; usually it occurs from indirect violence, as from falls, blows, or twists on the abducted arm. Muscular contraction as an origin is more common in this location than in any other bone; generally it is the outgrowth of efforts at throwing an object, or in trials of gripping strength, where the elbows are on the table and the opponents grasp hands and push or twist against each other.

Varieties and Sites.—Complete, simple, oblique, or spiral forms of the middle or lower third are commonest (Fig. 283). The amount of overlapping is determined generally by the extent of the violence and by the counter-pull of the pectoral (inward) and deltoid (up and outward) muscles; or the latter and the triceps in the lower levels (Figs. 284–286).

Symptoms.—*Deformity* shows by the attitude of the patient and the changed axis of the arm; *swelling* and *ecchymosis* later occur, and

the latter may be very marked. *False motion, local pain,* and *crepitus* are quite uniformly present. *Shortening* may amount to an inch or

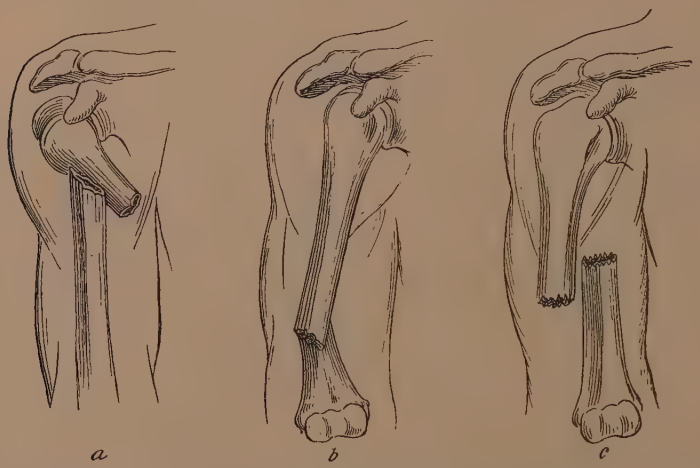


Fig. 283.—Lines of displacement in fracture of the shaft of the humerus: *a*, Fracture at upper third; *b*, fracture at lower third; *c*, fracture of middle of shaft.

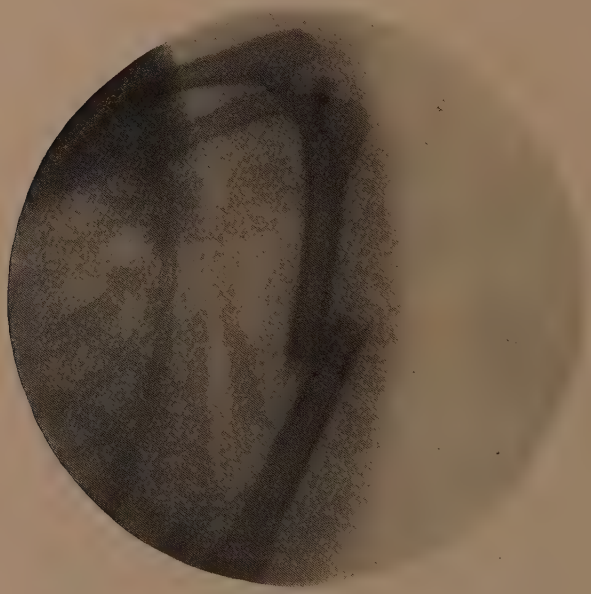


Fig. 284.—Fracture of humerus before reduction.

more between the tip of the acromion and the external condyle; in the middle line fractures there is usually not much displacement.

Treatment.—*Reduction* is made by traction and manipulation, usually under anesthesia, until the acromion and external condyle are aligned, bony crepitus is elicited, and shortening is overcome (Fig. 287). *Splintage* need be little more than placing the arm at the side and holding it there in cases with little displacement, thus using the chest for splintage, supporting the bent elbow and shoulder by a sling. In the average case some abduction by a triangular pad in the axilla and a shoulder-cap will be needed; hence treatment is practically that of

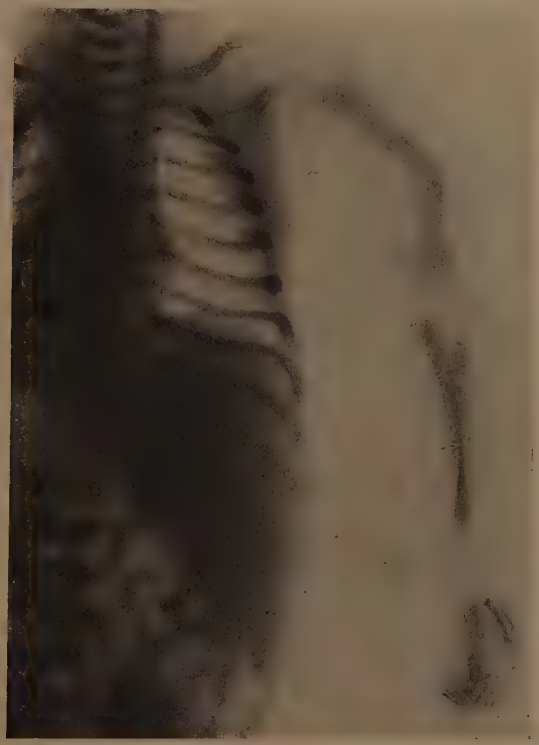


Fig. 285.—Fracture of the shaft of the humerus in an infant. This radiograph admirably shows the bony framework at this age.

surgical neck fracture, except that weight extension generally is unnecessary. In many cases abduction of the extended arm to a right angle and maintenance in this position by plaster of Paris from the wrist to the shoulder and about the body may be the best and most uniformly successful treatment, and this method is given preference by me (Figs. 281, 288, 289).

Operation to obtain reduction and maintain it by suture, pinning, or plating may be sometimes necessary.

Fig. 286.—Comminuted fracture of shaft of humerus.

Complications—Nerves.—The *musculospiral* may be affected at once from the initial violence, or soon after from swelling or efforts at reduction, or still later from pressure of callus or splints. Wrist-drop is the common sign of this condition with loss of thumb abduction and extension; there will also be numbness or tingling on the outer side of the forearm and hand, and back and outer side of the arm, atrophy appearing later. The *ulnar* and *median* are occasionally affected.

Before setting the bone the surgeon will do well to exclude any neural injury so that subsequent blame may be properly placed. It is generally wisest to wait several weeks before operating on such a

Fig. 287.—Reduction method for fracture of the humerus above the level of the condyles.

case of nerve palsy so that effusion or pressure from anything but callus may be excluded.

Blood-vessels.—Thrombosis or severing of the brachial artery has occasionally occurred; this shows itself by changes in the radial pulse, pallor, and coldness of the extremity, with signs of gangrene later.

Non-union.—This is more likely here than in any other bone, probably due to lack of complete fixation rather than to interposition of soft parts or nutrient artery damage.

Results.—Union is generally complete and solid in from four to six weeks; in children it occurs in three or four weeks.

The outcome is generally satisfactory as to appearance and function; stiffness of the shoulder or elbow, or both, usually are remedied

Fig. 288.—Incomplete reduction of a fracture of the shaft of the humerus.

Fig. 289.—Same case after reduction and retention in abduction plaster-of-Paris shoulder spica.

by time and forced motion. The original callus may be large and irregular, but in time it diminishes and becomes smooth.

Disability.—Total, four to eight weeks; partial, three to twelve weeks.

LOWER END

These forms vary greatly and may be associated with dislocation of the elbow. A great many confusing subdivisions are described and the nomenclature is not uniform; *clinically* the following are important and inclusive (Figs. 290, 291).

Supracondyloid.—This is the most common variety. The line of fracture is above the flaring surface of the condyles; it may be trans-

verse, oblique, or penetrate the joint, causing a so-called **T** or **Y** fracture, often comminuted.

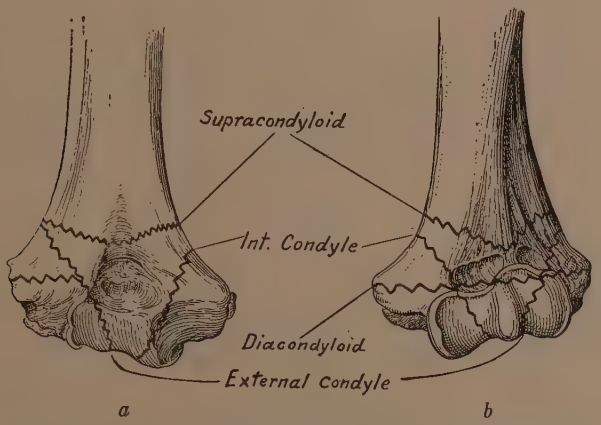


Fig. 290.—*a*, Lines of fracture of the lower end of the humerus, anterior view· *b*, the same, posterior view.

Some of these fractures are at a lower level, and are then known as "diacondylar" (Kocher), or "low supracondylar" (Stimson).

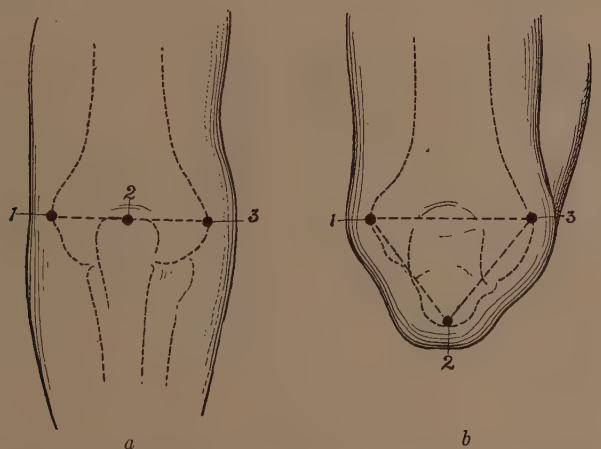


Fig. 291.—The relation of the bony prominences of the elbow to each other: 1, Internal condyle; 2, olecranon summit; 3, external condyle; *a*, with the elbow *extended*, these form a straight line—or with the elbow straight, they are straight; *b*, with the elbow flexed, these form a triangle—or with the elbow at an angle, they are at an angle.

Causes.—Falls on the outstretched hand or twists of the arm are the common sources; less often falls on the elbow may be productive. The former are called by Kocher the *extension* variety, and occur in

early life; the latter he calls the *flexion* variety, commoner in the aged (Figs. 292–297). *Direct violence* is most likely to produce **T**- or **Y**-shaped modifications, often compound (open).

Symptoms.—Deformity in the attitude of the patient and the elbow, with disability and pain are usually marked. False motion, crepitus, local pain, and irregularity are noted; elbow dislocation or

Fig. 292.—Supracondyloid fracture of the humerus.

fracture below the elbow is excluded by locating the three bony diagnostic points mentioned in the illustrations. Ecchymosis and blebs may appear later.

Treatment.—*Reduction* is by combined hyperextension, traction, and manipulation, and this is best done under anesthesia. Correction is purposely made so that the forearm tilts outward, in order that the normal relation of abduction of the forearm to the arm may be pre-

served. Normally the angle between the arm and forearm is about 160 degrees.

Forms of Splintage.—(1) The elbow is placed at a *right angle* and a *molded plaster-of-Paris* splint is applied to the front and back of each half of the arm, beginning just below the axilla, reaching to the wrist in front and beyond it behind. The forearm is abducted and in the position of mid-pronation and supination (thumb up). This antero-posterior splint is held by straps of adhesive and loosely bandaged, if at all. A sling is the final support.

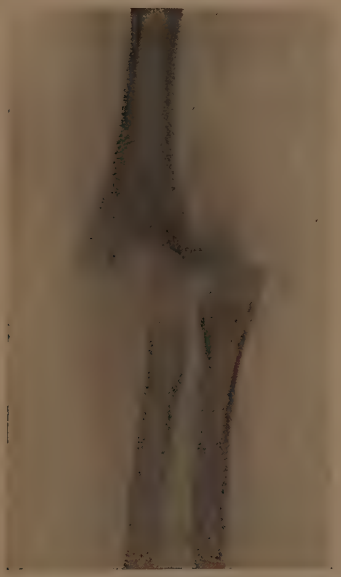


Fig. 293.—Postero-internal dislocation of the elbow with fracture of the internal condyle of humerus.

Fig. 294.—T-shaped supracondyloid fracture of the humerus.

(2) The elbow is flexed acutely *beyond* a right angle and maintained there by a gauze bandage or strap of adhesive with a pad in the fold of the elbow, this is the so-called "hyperflexion position" advocated by Jones, of Liverpool. The degree of flexion is up to a point beyond which radial pulsation ceases. Redressing is done in the same way on the third or fourth day, and twice weekly thereafter for over two weeks, the degree of flexion gradually being decreased, until at the end of four weeks the joint is at a right angle and a broad sling is then substituted for a week. Thus at the end of five weeks no dressing at all is used and

Fig. 295.—Supracondyloid fracture of the humerus showing partial union and imperfect correction.

Fig. 296.—Supracondyloid fracture of the humerus.

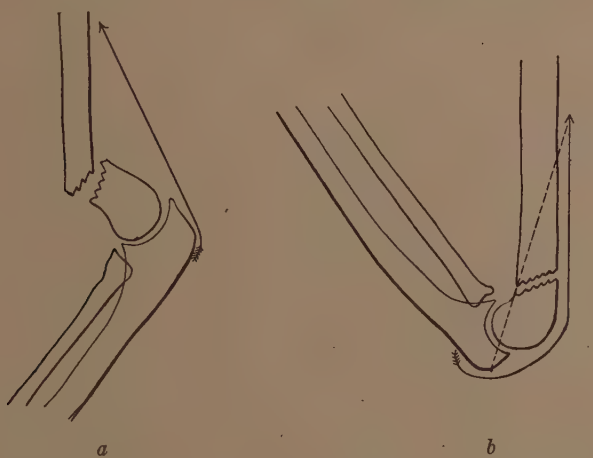
Fig. 297.—Case of T. C., aged fifteen. Comminuted fracture of the upper end of radius and ulna, and portions of each condyle of the humerus.

free motion is encouraged. No passive motion or massage is ever given early if pain, swelling, or heat are induced.

Plaster of Paris and rubber bands are also used to maintain this hyperflexed position (Fig. 298).

(3) *Extension* is made and, with the limb straight, wooden or plaster-of-Paris anterior and posterior padded splints are applied. These are worn three weeks and then some flexion motions gradually begin and are steadily increased. This method is hard on the patients; it is most valuable in fractures quite close to the joint.

My own preference is for the hyperflexion position, bending the elbow as far as possible and in such a manner that the bent forearm on the ulnar side will touch the outer margin of the shoulder.



a *b*

Fig. 298.—Action of triceps tendon in supracondylar fracture: *a*, Tendon on stretch, causing disjunction of fragments; *b*, tendon relaxed acting as an internal coaptation splint by hyperflexion of elbow. It is thus seen that hyperflexion causes the triceps to act virtually as an internal splint.

External Condyle.—This is the second commonest form. The line of fracture may involve the entire condyle from the center of the joint or split a portion of it. It is most often seen in the young.

Causes.—Falls on the palm of the hand with the elbow bent or stiff is *the* origin; it may also occur from falls on the elbow, or inward twists of the forearm.

Symptoms.—Deformity is variable; disability is nearly complete from pain and swelling, which are manifest chiefly on the outer margin of the joint, where ecchymosis later appears. Crepitus or false motion exist; intercondyloid pressure is painful; the fragment may be felt if much displaced; pronation of the forearm is painful.

Treatment.—Reduction by manipulation may be quite difficult and occasionally impossible without incision, if much rotation of the fragment has occurred. *Splintage* is by one of the *flexion methods* described. *Operative means* may consist of (*a*) removal of the fragment; (*b*) suturing, pinning, or plating it.

Internal Condyle.—This form is not especially common. The fracture line is more or less straight and enters the trochlear surface of the

Fig. 299.—Fracture of internal condyle of humerus (lateral and anteroposterior views).

joint at or near the center; avulsion forms chip off fragments of various sizes (Fig. 299).

Causes.—Falls upon or twists of the elbow are the common sources.

Symptoms.—Deformity varies; the elbow is usually held partially bent and is locally painful and swollen enough to produce disability. Crepitus, local pain, and mobility exist; intercondyloid pressure or that transmitted from the forearm is painful over the fractured area.

The ulna may also be broken; the ulnar nerve may give signs of involvement.

Treatment.—Reduction by manipulation is generally easy. *Splintage* is in a hyperflexed position, as in the preceding; operative maintenance of it may be required occasionally, and then pinning, wiring, or plating is done.

Epiphyses.—These fractures are quite common in children and resemble the supracondylar or condylar fractures in adults.

Anatomy.—Until about the third year the lower end of the arm is a cartilaginous mass and not separated into defined processes, and thereafter there may be epiphyseal separation of developed margins of the joint. The external condyle joins the shaft between the sixteenth and nineteenth year and the internal epicondyle is the last to unite.

Causes.—Falls, twists, and blows on the elbow or those transmitted from the hand are the most likely sources. This injury is commonest before the twelfth year, but may occur as late as the fifteenth to seventeenth, the epiphyseal line wholly disappearing at this latter period.

Symptoms.—Deformity is prominently indicated by the attitude of the patient and the swollen and perhaps discolored elbow. Crepitus if present is soft, the so-called "muffled crepitus"; false motion varies. Local pain on direct pressure, or that obtained by intercondyloid or upward pressure on the forearm also exists, but these may be misinterpreted on account of the youth of the patient. The joint may sometimes feel like a "bag of bones."

x-Ray examination is liable to cause very great confusion unless the normal epiphyseal lines are shown by an identical view of the opposite uninjured elbow; mere separation or a light or clear area on the plate is not diagnostic in the absence of actual displacement or malalignment.

Treatment.—Reduction may be easy to make, but hard to retain, or the reverse. Anesthesia is often quite necessary. *Splintage* in either of the *flexion* positions (preferably "Jones' position") is most advisable; the dressing must be examined often to relieve swelling or pressure, and it should be removed *promptly* for either of these or for great pain. Sometimes a gauze dressing wet with saline solutions is advisable for a day or two.

Epicondyles.—The *internal* or *epitrochlear* is rarely broken; it is more often affected in children than adults.

Symptoms and Treatment.—These correspond to internal condyle forms; *x*-ray or anesthesia diagnosis is usually needed.

External epicondyle fracture is even rarer than the foregoing, and the *diagnosis* is extremely difficult and is generally academic more than clinical, and depends on *x*-ray or operative demonstration; in general, the *signs* and *treatment* resemble *external condyle* forms.

Capitellum fractures are clinical curiosities.

SUMMARY OF HUMERUS FRACTURES

Upper end involvement is commonly of the surgical neck, and here associated dislocation or fracture must be excluded.

Outcome depends on the success of reduction; reasonably early massage and passive motion are helpful, and even with considerable restricted motion at first, a good end-result is obtainable if active motion is persisted in.

Shaft involvement generally causes no diagnostic difficulties, and proper treatment brings about excellent results in the majority of cases, even though delayed or non-union prolongs the eventual outcome.

Lower end involvement is generally the *supracondylar* or *external condyle* forms in adults; before twelve, an epiphyseal form is most likely, and this in children under four years consists of the entire epiphysis (corresponding to supracondylar forms), and at other ages is most liable to show separation on the outer side of the joint. In all, dislocation and associated involvement of the head of the radius or olecranon region must be differentiated, and usually this demands proper *x*-ray interpretation. Early massage or forced passive or active motion is generally inadvisable, as the weight of the forearm seems to afford quite enough motion for the first six weeks. Splints are removed after three or four weeks in all patients.

The early results are liable to be bad, especially in children; but after six months most joints recover as to appearance and function. *Deformity*, especially an inward tilting of the axis of the forearm, producing *cubitus varus* (gun-stock deformity), occurs practically only in *supracondylar* forms due to ascent of the condyle; it is best prevented by maintenance of proper reduction and a position of overabduction of the forearm.

Examinations of the elbow are much facilitated by sitting behind the seated patient whose elbows are held in a right-angled position on the examiner's knees.

Practically speaking, my practice is to treat fractures of the lower articular end of the arm in the position of hyperflexion ("Jones' position"); fractures above this level that require correction are treated

in a position of right-angled abduction. *In all forms, the key to success is proper reduction.*

Fractures of the Forearm

These are very common injuries, comprising 331 cases in my list, a percentage of 6.6. Either the radius or the ulna may be separately involved at the upper or lower end; but in the shaft both are likely to be broken together.

Anatomy and Landmarks.—The *ulna* enters into the formation of the elbow-, but not of the wrist-joint. The *radius* enters into the formation of the wrist-, but not of the elbow-joint; hence elbow fracturing violence is liable to involve the ulna, and wrist violence the radius. *Upper end landmarks* have already been spoken of. *Head of radius* can be felt behind and below the external condyle, and sometimes rotation is visible. *Shaft of radius* and *ulna* are palpable in the lower two-thirds especially, notably laterally and posteriorally.

Lower End.—Styloid of radius is palpable and is larger, lower, and more posterior than that of ulna; the tip of the radial is from ½ to ¾ inch lower than the opposite styloid. *Styloid of ulna* is also palpable and is quite easily seen as a knob on the back of the wrist. *Wrist wrinkles* are seen on the front of the slightly flexed joint and changes in their appearance and location are often suggestive.

Upper-end Fractures.— Ulna: Olecranon or coronoid process. *Radius:* Head or neck.

Olecranon Fracture

This is the commonest fracture hereabouts, and the line of breakage is usually at the base, but cleavage may be higher up with fragments of various sizes (Figs. 300–302).

Causes.—Direct falls on the elbow is the common source; less often a transmitted fall from the hand is at fault. Very rarely triceps muscular action pulls away a segment from the top, as in throwing or straining efforts. Sometimes it is of the compound (open) variety from a direct impact.

Symptoms.—*Deformity* indicated by the attitude of the patient and the changed contour of the back of the joint, with much *disability* from pain and swelling, are usual. Crepitus and false motion exist, especially in the separated forms; there is usually not more than ½ inch separation even in marked cases because the pull of the triceps upward is limited by the ligamentous and other soft part attachments.

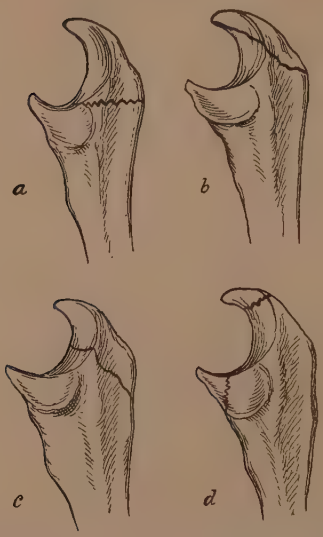


Fig. 300.—Fracture of the olecranon: *a*, Cleavage at the base (common form); *b*, avulsion form at summit; *c*, cleavage at the center; *d*, cleavage at the tip and of the coronoid process.

Fig. 301.—Fracture at the base of the olecranon and head of radius (lateral and anteroposterior views). Note the small displaced fragment of radial head indicated by the white **V** mark; this necessitated operative removal, as it would have "locked" the joint during flexion.

Treatment.—*Reduction* is generally easy, either by straightening or overbending the joint. *Splintage* can be done in several ways: (1) The joint is flexed beyond a right angle and kept so by anterior and posterior molded plaster-of-Paris or metal splints reaching from the upper third of the arm to the wrist (like that for supracondylar fractures). If the fragments are not brought together by flexion of the joint, they can be coapted by straps of adhesive plaster which, however, must not encircle the limb. (2) The elbow is held straight or nearly so, and posterior or anterior and posterior molded plaster or

Fig. 302.—Comminuted fracture of the olecranon and coronoid processes of ulna.

padded wooden splints are applied, covering the same area as the foregoing (Fig. 303). Adhesive plaster may be used if needed to aid coaptation. This splintage is useful mainly where there is much separation and when any other position increases rather than diminishes it. (3) *Hyperflexion* in "Jones' position." (4) *Operation*, by which the fragments are joined by kangaroo tendon, wire, nails, or plates. Splints are worn three or four weeks and then some gradual use begins.

My personal preference is for operation in selected cases.

Results.—Union is very rarely immovable or bony, and the inter-

vening fibrous band, like that in the patella, may vary in length, width, and consistencey, but this by no means predicates future disability.

Healing is complete in three or four weeks and at first there will be a good deal of stiffness and lost power. The end-results are usually

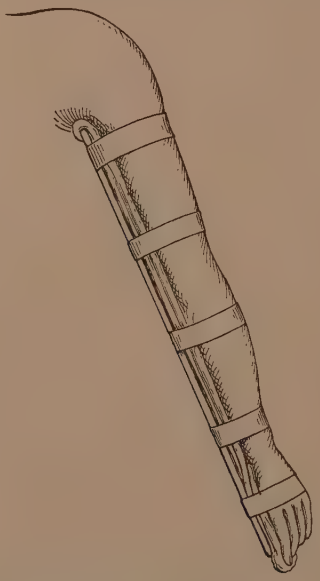


Fig. 303.—Extension splint for fracture of the olecranon.

good; in the widely separated cases there may be a knobbed deformity and limited triceps action, requiring adaptation on the part of the patient.

Disability.—Total, four to six weeks; partial, two to eight weeks.

CORONOID FRACTURE

This is exceedingly rare except when associated with backward dislocation of the ulna; *x*-ray diagnosis is necessary for confirmation.

Causes, Symptoms, and Treatment.—Transmitted falls are the usual origin, and the *signs* are those of backward dislocation, with the possible association of a hard body felt in front of the joint on a line with the attachment of the brachialis anticus muscle, and this area is likely to give local tenderness and false motion.

Immobilizing the joint in a flexion position is the *treatment;* if the fragment fails to unite or acts as a foreign body, operation may be necessary to suture it in position, or to remove it.

Results vary; if reduction can be maintained, it will be good, otherwise some stiffness is likely to persist.

HEAD OF RADIUS FRACTURE

This is a rather rare form of fracture requiring *x*-ray determination usually. It may involve the edge or cup of the head to varying degrees (Fig. 304). Direct blows or forcible twists are the usual sources; transmitted falls rarely are to blame. Frequently it is associated with backward dislocation of both bones of the forearm.

Signs are local tenderness, crepitus, and false motion, especially marked in cases with much displacement when the fragment can be felt. Pain localized on rotating the wrist is often suggestive.

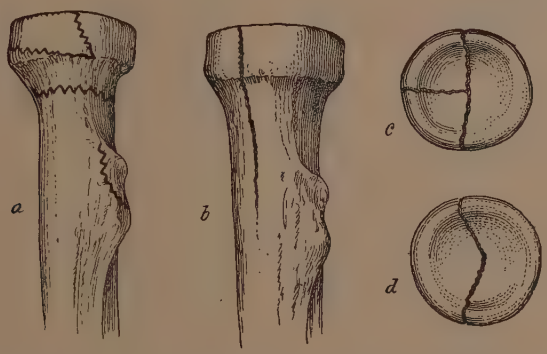


Fig. 304.—Fracture lines of the upper end of the radius: *a*, At the head, neck, and tuberosity; *b*, at the head extending to the shaft; *c*, *d*, at the head, viewed from above.

Immobilization in a position of flexion or extension is the treatment when such procedure restores the fragments to position. If wholly detached, *operative removal* is wisest because bony union is unlikely and the fragment then acts practically as a foreign body.

NECK OF RADIUS FRACTURE

This is rarer even than the preceding, but the causes, signs, and treatment are practically the same. The diagnosis is made usually by *x*-ray examination.

SHAFT FRACTURE

This may involve either or both bones, most commonly in the middle or lower third, and when both are broken the radius is broken higher up than the ulna as a rule (Fig. 305).

Causes.—Direct falls or blows or bends are more common sources than transmitted impact from the hand or elbow.

Varieties.—Complete, transverse, or oblique forms of both bones are the commonest (Fig. 307). Overriding of several inches may

occur. Compound (open) forms are very common from crushes, severe falls, vehicular, and machinery accidents. Rotatory displacement of the radius alone may occur when the line of breakage is above the insertion of the pronator radii teres (about the middle) (Fig. 307).

Incomplete or *greenstick* forms are more common here than in any other location; they occur before the fifteenth year, generally from falls on the hand or bending forces. Bony union is complete in each bone at the twentieth year, the lower epiphyses being the last to join (Figs. 308–310).

Fig. 305.—Usual fracture sites in ulna and radius.

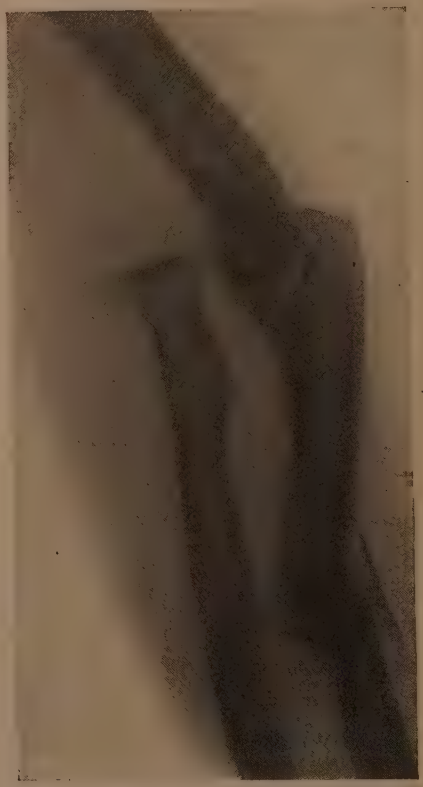


Fig. 306.—Fracture of ulna. Note small fragment at posterior margin.

Symptoms.—*Deformity* in the helpless limb and the attitude of the patient is generally marked. Swelling, ecchymosis, and blebs soon appear. Crepitus, false motion, and local pain exist; irregularity and definite outlining of the fragments can often be determined by palpation and sometimes by inspection. Measurement shows shortening. In fracture of a single bone with little or no displacement, transmitted pressure by jamming the wrist toward the fixed elbow (or the reverse)

will elicit suggestive local pain; likewise lateral pressure of one bone against the other causes pain.

Direct violence is more likely to break one bone than both, the ulna far oftener suffering.

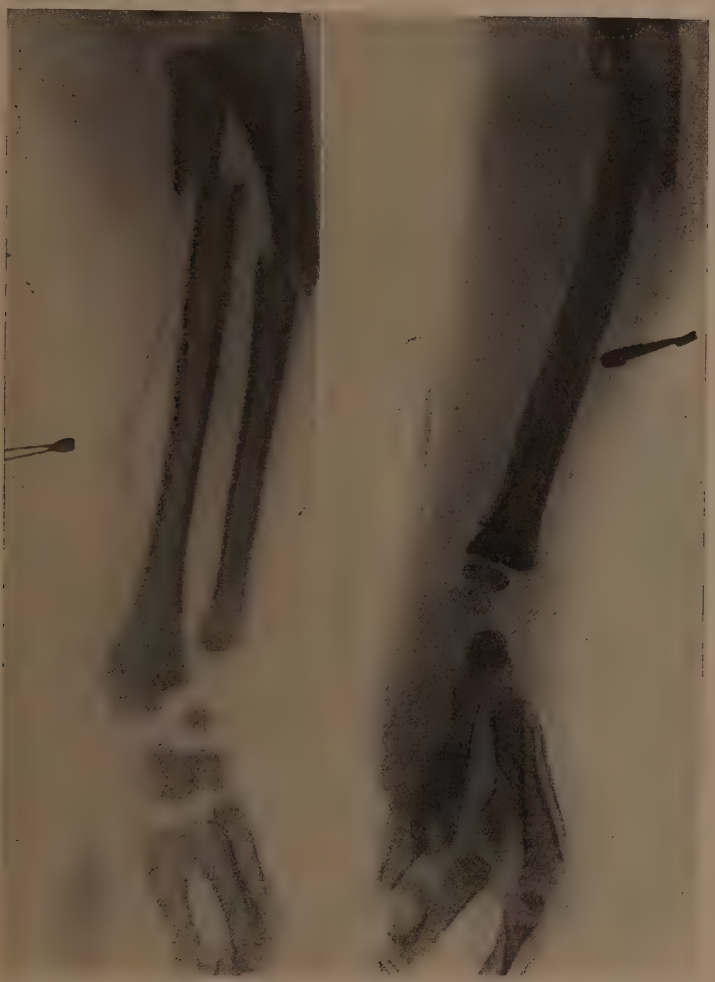


Fig. 307.—Fracture of upper third of ulna and radius in a child (lateral and anteroposterior views). Treatment indicated: reduction by traction; anteroposterior molded plaster-of-Paris splints (with elbow at right angle), from middle of arm to web space of palm, thumb up.

Treatment.—*Reduction* is by traction, flexion, or manipulation; anesthesia is advisable to relax the muscles, although this to some extent can be accomplished by (1) hanging a dangling weight to the wrist; (2) shutting off circulation by a tourniquet above the elbow

until the "fingers feel asleep"; (3) by freezing the part in a mixture of salt and ice.

Splintage is by (1) anterior and posterior molded plaster-of-Paris splints reaching from or just above the elbow to the web of the fingers in front, and 1 inch lower behind (Fig. 311). In fractures above the middle it is wisest to carry the anterior splint as high as the middle of the arm. The position of the limb is midway between pronation and supination (thumb up), and the elbow is bent nearly to a right angle.

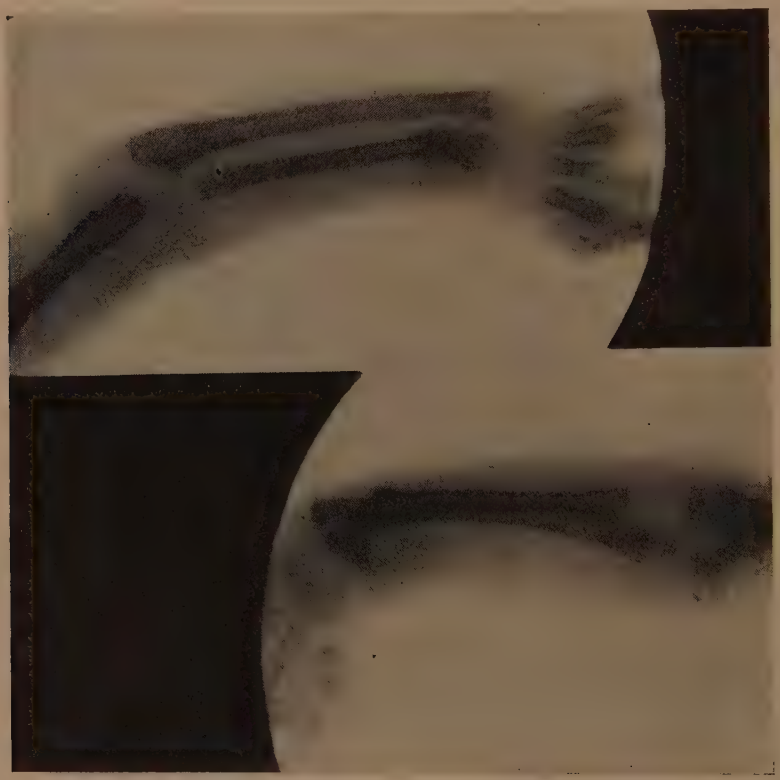


Fig. 308.—Greenstick fracture of the lower end of the radius.

No bandage should be used under the splints, and the latter may be held in place by straps of adhesive spirally placed so that no pressure is applied on or near the fracture, and thus circulation is unaffected. The limb must be carefully held until the splints harden. A *broad* sling reaching well below the wrist and above the elbow completes the dressing. The patient is told to keep the fingers wiggling from the first.

(2) Padded broad wooden or other splints reaching from above

the elbow to the same lower limits as the preceding may also be used (Fig. 312).

(3) *Operation* is occasionally needed where reduction cannot otherwise be made, and then suturing by kangaroo tendon or wire plating is done. It is called for chiefly in vicious or non-union cases. Encircling plaster-of-Paris or other dressing, hiding the part, are dangerous and unnecessary.

Fig. 309.—Greenstick or subperiosteal fracture of the radius and ulna.

Fig. 310.—Fracture of radius (complete) and ulna (incomplete, or greenstick).

The patient should be instructed against early signs of pressure (tingling, change in the color of the fingers, or local pain and swelling), and if this does not subside on elevating the limb, the splint must be removed forthwith; it is better to instruct the patient to remove it immediately rather than await the physician's arrival at a time when the damage may be already done.

In fractures *above* the middle, or at a point higher than the attachment of the pronator radii teres, it is advisable to splint in a position of *supination* to prevent interosseous fixation or faulty rotation of the radius.

Greenstick forms that are not readily straightened are often best converted into the complete type by bending under anesthesia.

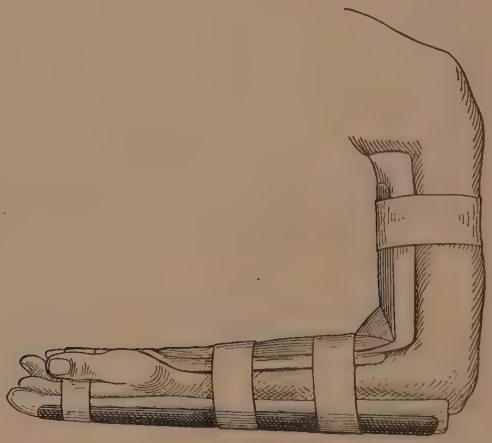


Fig. 311.—Dressing for fracture of the forearm by padded plaster-of-Paris, metal, felt, or wooden splints.

Treatment for these is the same as for the others, except that splints are not used for so long a period.

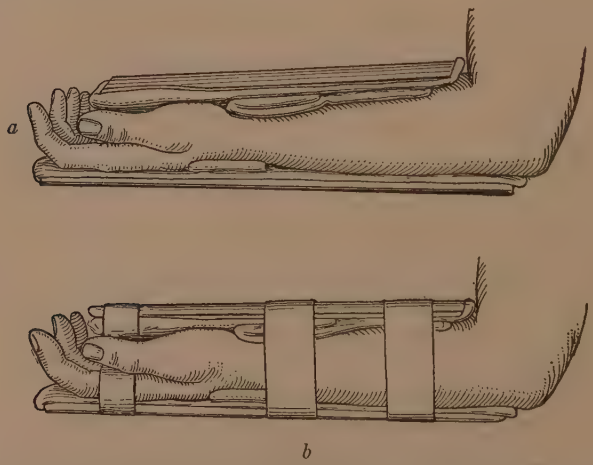


Fig. 312.—Padded plaster-of-Paris, metal, felt, or wood splints for wrist fractures: *a*, Proper arrangement of padding and relation of end of splints to allow free finger and elbow motions; *b*, proper position of adhesive straps.

Complications.—*Pressure* from dressings earlier causes damage here than in any other location, and may thus lead to the *ischemic contracture of Volkmann*, which is characterized by local cyanosis, atrophy,

and a claw-like contracture of the fingers without neural involvement. This condition is probably due to a degenerative myositis, and may be irremediable even by prolonged massage, forced use, tenorrhaphy, osteotomy, or special apparatus.

Interosseous union by callus between the radius and ulna occurs rarely; it may be considerable without greatly interfering with rotatory action.

Non-union is rather unusual; it is more common in the radius. Three weeks of other treatment should be given before operative measures are decided upon for its relief.

Results.—Union is complete in three or four weeks, and then the anterior or both splints should be removed and the sling used for a week or two longer. After the first week, splints should be removed once or twice a week for inspection and massage.

Bowing or *tilting* sometimes persists, and at first *rotation* will probably be limited. Secondary bowing occasionally occurs if the limb is forcibly used too early. The end-results functionally are generally good even when the external and *x*-ray appearances seem to indicate otherwise.

Disability.—Total, six to eight weeks; partial, two to ten weeks.

COLLES' FRACTURE

This break within the lowest inch of the radius is the commonest of the extremities, and in my statistics ranks third of all, a percentage of 8.2. Of all fractures various authors rank it as second, third, or fourth in frequency.

The lesion was formerly regarded as a backward dislocation, and it derives the name from Colles, the Dublin surgeon, who in 1814 determined its true nature, differentiating it from backward dislocation of the wrist.

This injury should be excluded in every disabling or deforming wrist injury before a diagnosis of contusion, sprain, or dislocation is made.

Clinically, it includes all those fractures occurring within the lowest inch of the radius.

Causes.—Falls on the palm or ball of the thumb with backward bending of the wrist is *the* cause, and it usually results from on effort at protection after tripping or stumbling on an irregular surface or step. Very rarely it may follow a direct blow.

The condition in general is quite similar to, and for all practical purposes can be regarded as, the "upstairs" form of Pott's fracture of the ankle.

Varieties.—The *line* of breakage is almost always within an inch of the lower articular surface, and it is usually *transverse*, but may be

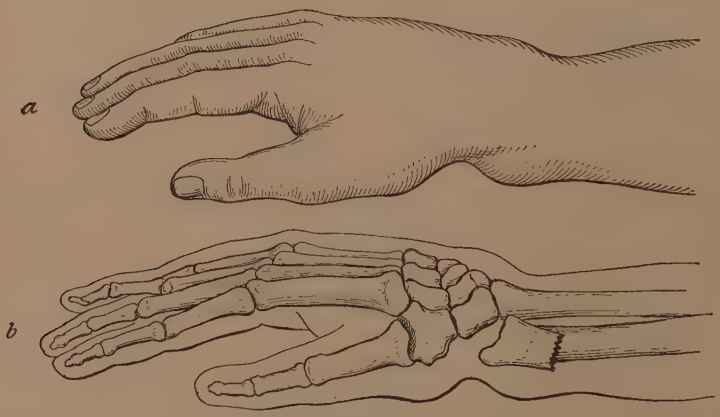


Fig. 313.—Colles' fracture (displaced variety): *a*, Deformity of soft parts; *b*, deformity of bone.

oblique and is often *comminuted* or *impacted*. In many cases the styloid of the ulna is also broken.

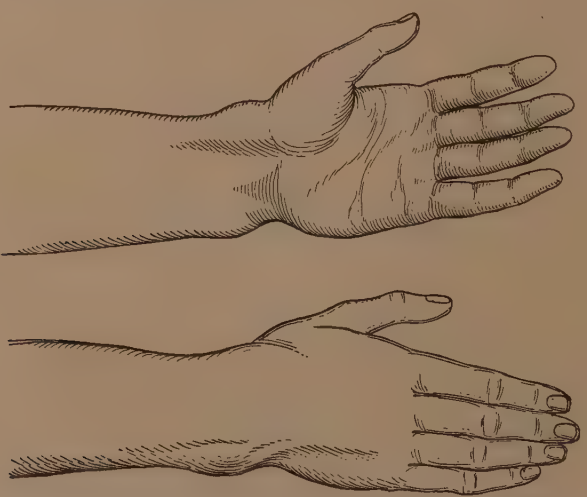


Fig. 314.—Colles' fracture deformity in a typical case. Note the outward tilt of the entire hand (abduction attitude) and the widening of the wrist.

Displacement of the lower fragment is usually angular, turning upon its anterior edge hinge-like, so that the articular surface looks down and back instead of down and forward (Stimson). Backward displacement is the second commonest form. Ligamentous involve-

ment is rather rare; the internal lateral ligament is the most likely to participate.

Modifications of the usual forms go by the name of "modified Colles'" or "reversed Colles'" fractures.

Fig. 315.—Fracture at lower end of radius and ulna (impacted—lateral and anteroposterior views). Treatment indicated: Reduction by traction, adduction, and palmar flexion; anteroposterior molded plaster-of-Paris splints from below bend of elbow to web space of palm; forearm in midpronation (thumb up).

Symptoms.—*Deformity* in the disabled attitude of the patient and wrist is characteristic, and from it alone the diagnosis can frequently be made, inasmuch as there is sometimes a humped *swelling* on the back of the wrist and a bowing of the partly bent hand; this swelling

is the so-called *silver fork* deformity so rarely seen and so often expected (Figs. 313, 314). But this deformity is not nearly so constant as a shifting outward (thumbward) of the entire hand, with the ulna styloid unduly prominent. The *wrinkles* on the front of the wrist are often less prominent. Palpation shows a *change in the styloid levels*

Fig. 316.—Compound comminuted fracture at the lower end of the radius and ulna (lateral and anteroposterior views). Patient, female adult, who fell one flight of stairs.

so that they are on the same line, or the radial styloid may even rise the higher. The anteroposterior *width* of the lower end of the bone is increased. There is quite regularly a sense of fulness over the front of the wrist just above the skin creases; this is often visible.

False motion and *crepitus* are rare.

Local pain is present on direct pressure, or that transmitted from the ball of thumb or laterally over the wrist. *x*-Ray examination to

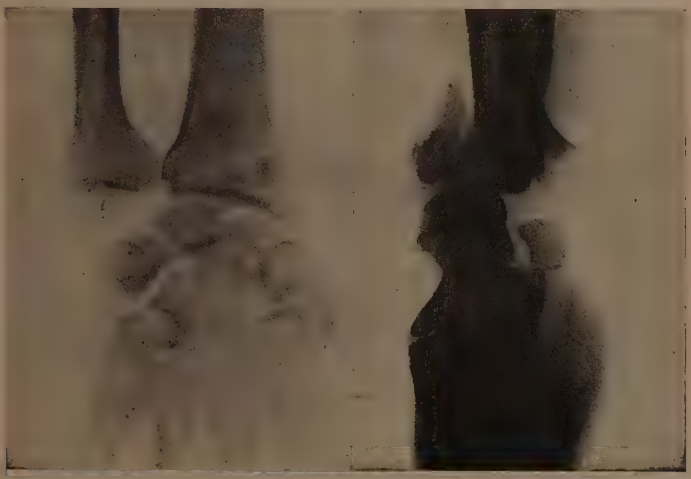


Fig. 317.—Colles' fracture with comminution of radius and avulsion of ulna styloid. Anteroposterior view shows little vertical, but much outward displacement. Lateral view shows much backward displacement.

be helpful must be in two axes, side to side and from before backward; it is most valuable after reduction, but even then may be decep-

Fig. 318.—Colles' fracture with comminution of radius and avulsion of ulna styloid. After reduction. Note that a line dropped downward from the inner side of radius now strikes the third knuckle and not the second; and that the backward displacement is corrected.

tive and should not wholly supersede the ordinary clinical evidences (Figs. 315–320).

Fig. 319.—Colles' fracture (impacted) with avulsion of the tip of the styloid process of the ulna.

Fig. 320.—Colles' fracture (impacted).

Fig. 321.—Reduction of Colles' fracture. First step: Increasing the deformity by pushing the hand *backward* and *outward*.

Fig. 322.—Reduction of Colles' fracture. Second step: Traction downward.

Treatment.—*Reduction* is the main essential, and if this is successful it makes little difference what other means are used. Anesthesia is

advisable. The first step in the *reduction* is to *increase the deformity;* thereafter several procedures may be tried, such as: (1) Direct trac-

Fig. 323.—Reduction of Colles' fracture. Third step: Palmar flexion and inversion, bringing the hand *forward* and *inward*—the "mailed fist" position.

Fig. 324.—Reduction of Colles' fracture. Fourth step: Position maintained by grasping a rolled bandage or piece of wood.

tion on the hand and wrist and downward pressure over the lower fragment; (2) manipulation so that lateral and flexion motions are combined with traction; (3) circumduction to break up impaction, com-

bined with traction and pressure if necessary (Figs. 321–324). Sometimes a Thomas (Fig. 325) wrench may be used as a lever.

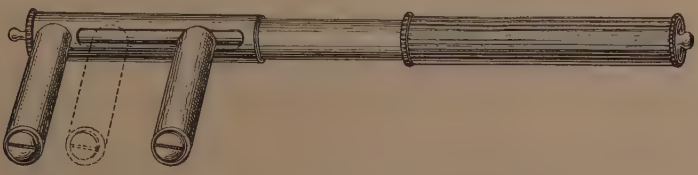


Fig. 325.—Thomas' wrench, showing sliding prong.

Whatever the method, setting has not been successful unless the following "tests of setting" exist: (*a*) Crepitus is demonstrable; (*b*)

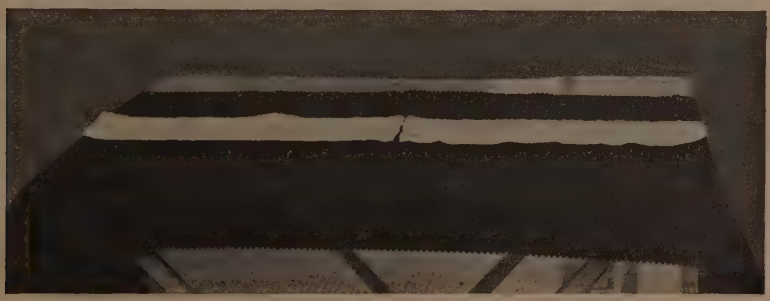


Fig. 326.—Preparation of a "molded plaster-of-Paris splint" for Colles' fracture. Sheet lint or wadding strips to form the foundation.

the styloids are restored to their normal levels; (*c*) deformity disappears; (*d*) the vertical axis of the middle of the forearm is on a line with

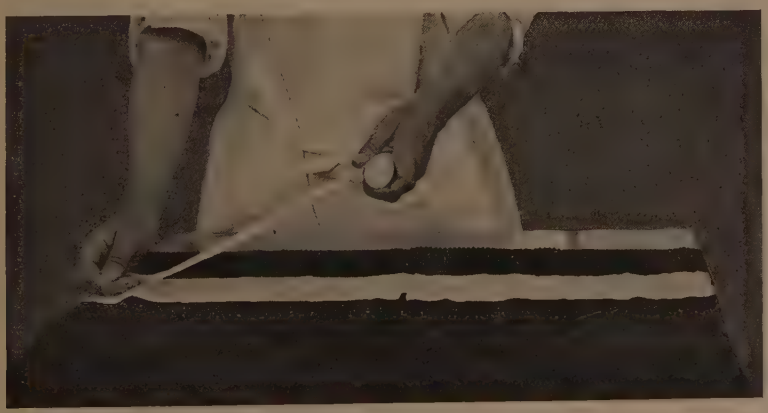


Fig. 327.—Preparation of a "molded plaster-of-Paris splint" for Colles' fracture. Wet plaster-of-Paris bandage being folded atop the foundation.

the middle finger; (*e*) the hand can be held in the same straight line as the forearm by the weight of the surgeon's index-finger.

Splintage.—A position of some palmar flexion with the hand tilted toward the ulnar side is advisable; or the position of full extension may be used. The essential is to overcorrect the deformity and keep it thus.

Fig. 328.—Preparation of a "molded plaster-of-Paris splint" for Colles' fracture. Ready to be applied.

Splints may be of (1) *molded* plaster of Paris reaching from below the bend of the elbow to the web of the fingers in front and an inch lower behind (Figs. 326–329).

(2) Anteroposterior *board* splints covering the same limits as the foregoing and cut to allow the ball of thumb to sink in.

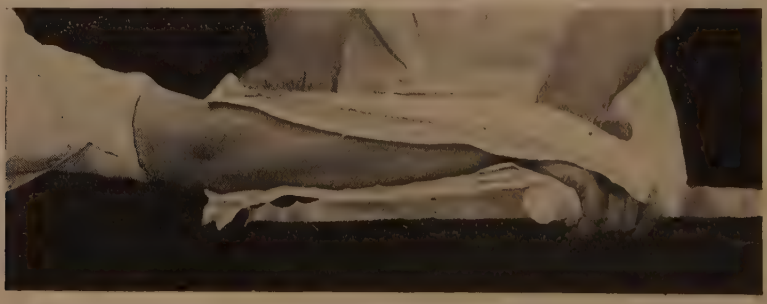


Fig. 329.—Preparation of a "molded plaster-of-Paris splint" for Colles' fracture. Applied to front and back of forearm. Note bandage gripped in patient's hand to maintain the position of palmar flexion and adduction. The plaster is now held by a bandage until it sets.

(3) *Special metallic* and *circular bands* of plaster of Paris or *adhesive* covering the wrist and small areas above and below it; these are not usually efficient or comfortable. Moore's dressing is of this type (Figs. 330–332).

The original deformity is *up and out;* the aim is to overcorrect this into a position of *down and in*, and safely and comfortably hold it thus.

Fig. 330.

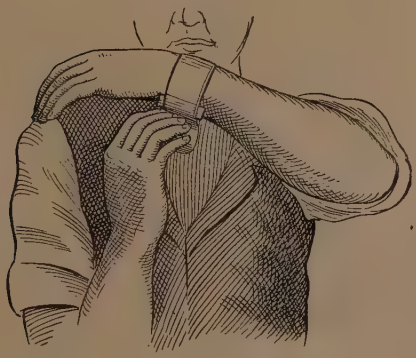


Fig. 331.

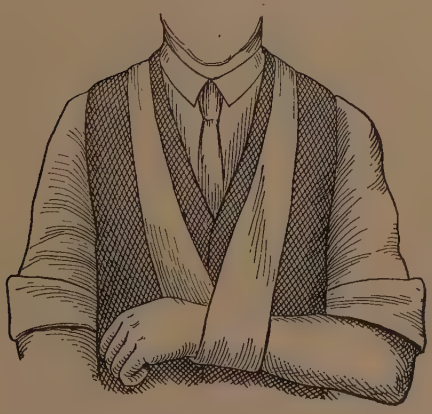


Fig. 332.

Figs. 330–332.—Moore's dressing and sling for Colles' fracture.

After-treatment.—Precautions are needed to prevent pressure effects, which soon lead to deformity and disability, and hence the dressing

should be inspected often and removed once or twice in the first week. If the molded plaster-of-Paris splints are used, this removal is easily accomplished by cutting one side of the adhesive straps and lifting half of the splint like the lid of a hinged box. Massage can be given within a few days and some slight passive motion can follow on the twelfth or fourteenth day, each to be used twice or thrice weekly or even daily. The posterior splint can be removed at the end of the second or third week, and all support is off at the end of the fourth week. Then a strap of adhesive or a leather band may be worn on the wrist for a week or two if desired.

The fingers are kept actively wiggling from the first, and if this is done tenosynovitis will be limited or wholly prevented.

Results.—Union is complete in three or four weeks. There is liable to be a good deal of swelling and stiffness of the wrist and fingers after removal of the splints, especially in old people; a great deal of this is prevented if early massage and motion is given and if the splints are not kept in place longer than indicated. Stiffness of the wrist and fingers is more often the fault of the surgeon than the fracture.

Tenosynovitis generally means prolonged splintage and failure to employ massage and motion. A great improvement in it is possible by enforced use and massage or from the use of baking, a wrist-machine, or gymnastic movements.

Deformity may persist as a bony thickening or definite swelling. There may be an undue prominence on the back of the wrist or a raised ulna styloid. Some cases show a forward bowing and puffiness on the front of the wrist and a tilt of the hand outward. Most of these are proportionate to the success in setting. Bad appearance does not mean disability, as many untreated and badly set cases are functionally perfect. Deformity of this sort in the young may disappear; in adults and the aged it is likely to persist.

Disability.—Total, four to eight weeks; partial, two to six weeks.

"CHAUFFEUR'S FRACTURE"

This occurs from starting handles of automobiles, motor-boats, and gasolene engines. There are two forms:

(*a*) From *indirect violence* due to a "kick-back" from the handle at the height of compression so that the ball of the thumb is thereby jammed backward.

(*b*) By *direct violence*, as the handle rotates and strikes the forearm above the articulation.

In (*a*) there is usually a **V**-shaped fracture of the articular surface

Fig. 333.—"Chauffeur's fracture" of the lower end of the radius.

Fig. 334.—"Chauffeur's fracture" of the lower end of the radius.

of the radius with some displacement, and a crack of the ulna styloid (Figs. 333, 334).

In (*b*) one or both bones are broken at the lower third.

Symptoms and **treatment** are the same as in Colles' and fracture of the shaft of the forearm respectively.

Preventive measures require engines to be started by a *pull up* and not a *push* or *spin* of the handle. If the left hand is used this fracture is far less likely.

Fig. 335.—Fracture of the styloid process of the radius (comminuted).

BARTON'S FRACTURE

This was described by Dr. Rhea Barton, of Philadelphia, in 1838. It was supposed to represent a fracture of the posterior border of the articular surface; the reverse of this is called a "reversed Barton's fracture." Stimson says it is really a complication of backward dislocation of the wrist, and he has seen but 2 cases of it.

Causes, symptoms, and **treatment** do not need special separation from Colles' fracture or its modifications.

ULNA STYLOID FRACTURE

This is rather uncommon as an isolated injury, but often accompanies a Colles fracture or wrist dislocation. Sometimes it may occur as an example of "sprain-fracture" due to being avulsed by the superior strength of the internal lateral ligament.

Causes, symptoms, and **treatment** are included in Colles' fracture.

Radial styloid fractures fall into the same group as the preceding (Fig. 335).

SUMMARY OF FOREARM FRACTURES

Upper end is likely to involve the olecranon.

Shaft is most likely to be broken about the middle, both bones usually are involved.

Lower end practically is always a Colles or a modification of same. Outcome is predicated upon the success of reduction; splintage must be very carefully watched to prevent serious pressure effects, notably Volkmann's ischemic paralysis. In all forms there may be some deformity, especially at first, but the final outcome as to function is usually good.

CARPAL FRACTURES

These are not so uncommon since *x*-ray confirmation has been obtainable.

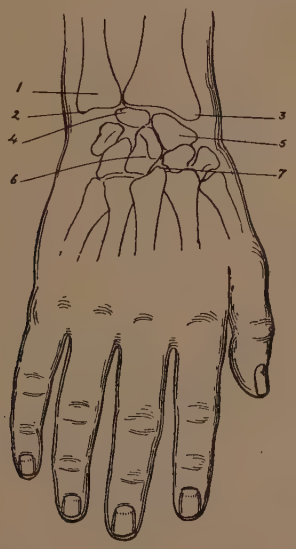


Fig. 336.—Carpal bones in relation to radius, ulna, and metacarpals: 1, Lower end of ulna; 2, ulna styloid; 3, radius styloid; 4, semilunar; 5, scaphoid; 6, os magnum; 7, trapezoid.

Of the eight bones, those of the upper row are most frequently broken; the order of frequency is scaphoid, semilunar, pisiform, os

magnum, trapezium, trapezoid, unciform, and cuneiform (Codman and Chase) (Figs. 336, 337).

Causes.—Direct violence is less often responsible than falls on the hand or ball of the thumb, and, indeed, the source of origin is not unlike Colles' fracture.

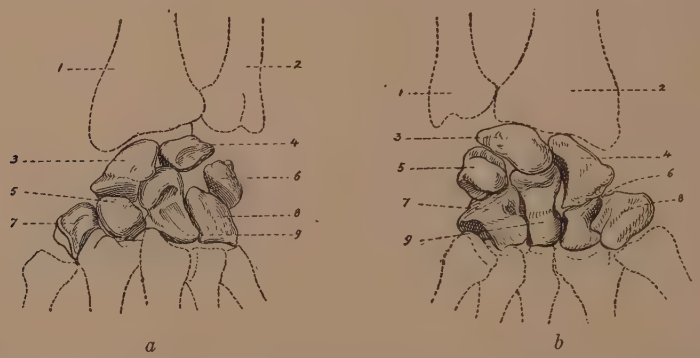


Fig. 337.—Carpal bones: *a*, Anterior view: 1, Radius; 2, ulna; 3, scaphoid; 4, semilunar; 5, trapezoid; 6, cuneiform; 7, trapezium; 8, unciform; 9, os magnum. *b*, Posterior view: 1, Ulna; 2, radius; 3, semilunar; 4, scaphoid; 5, cuneiform; 6, trapezoid; 7, unciform; 8, trapezium; 9, os magnum.

The scaphoid and semilunar are affected more frequently than all the others combined, and each may be associated with dislocation. Young male adults seem most prone, and the right wrist is the more often affected.

SCAPHOID FRACTURES

The signs may simulate a Colles fracture, and the differentiation is made by finding: (1) Localized swelling behind and below the radial styloid; (2) local extreme pain on pressure in the "snuff-box" triangle between the thumb and its extensors; (3) fulness of the "snuff-box" area; (4) tension, spasm, or pain of extensors of the thumb; (5) *x*-ray diagnosis is confirmatory (Figs. 338, 339).

A good many of these cases are self-treated for a sprain, and then relief is sought after a few weeks because of localized pain and inability to use the outer side of the wrist and thumb. This recurrent pain and disability is most marked when lateral flexion of the wrist or abduction of the thumb is made, as in throwing or lifting, tennis, and golf.

Treatment.—*Reduction* may be impossible without incision; sometimes pressure alone is effective.

Splintage is like that for Colles' fracture. If more than three weeks elapses without treatment, non-union is likely and excision of the

bone is wisest because it will probably continue to act as a disabling foreign body. The results after partial or complete removal are good.

Fibrous union alone occurs, but it is effective if displacement has been corrected.

Results.—If seen early and if reduction can be made, the outcome is good and function is perfectly restored. Late cases seem best

Fig. 338.—Fracture of the carpal scaphoid.

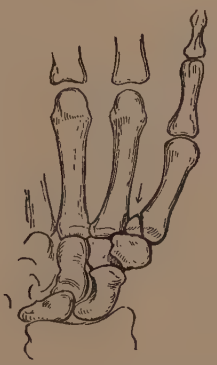


Fig. 339.—Fracture of the base of the first or thumb metacarpal (Bennett's fracture).

treated by operation, otherwise there is likely to be permanent swelling and disability of varying degrees.

Disability.—Total, four to six weeks; partial, two to four weeks.

SEMILUNAR AND OTHER CARPAL FRACTURES

These generally accompany dislocations or are associated with other fractures. Isolated fractures are clinically too rare for separate description.

METACARPAL FRACTURES

Of this relatively uncommon type, the third and fourth are most often involved; the thumb and little finger metacarpals are least affected. In many it is an associate of compound crushes and multiple fractures. The middle part is usually broken (Fig. 340).

Bennett, of Dublin, describes a special form of fracture through the base of the thumb, and this bears the name of "Bennett's fracture" (Fig. 339).

Causes.—Commonly they occur from direct or indirect blows or falls; less often it is due to twisting motions of the fingers (Fig. 341).

Knuckle fracture is common in pugilists.

Symptoms.—Deformity is shown by swelling and perhaps some visible change in outline; crepitus, false motion, local pain, and irregularity are also usually elicitable.

Fig. 340.—Common sites of fracture of the fingers or metacarpals.

Local pain obtained by upward pressure on a finger or squeezing the palm is quite suggestive in those suspected cases which show few

Fig. 341.—Fracture of the fourth metacarpal at the site of pre-existing bone-cyst. Patient was a laundress, aged twenty-six, and she sustained the injury while wringing a wet towel. Treatment instituted: Anterior padded wooden splint for hand and forearm. Excellent result.

other signs. Shortening is often best shown by comparing the level of the finger-tips.

Treatment.—*Reduction* is usually easy by flexion of the fingers with or without traction and pressure.

Splintage is made by (1) Padded palmar splint and a gauze dressing; (2) a ball, roll of gauze, or other material is placed in the palm, and the clenched fingers and hand are fastened to it (Fig. 342, *b*); (3) sections of rubber tubing are fastened in the intermetacarpal spaces on the back of the hand and an anterior splint or bandage is used for reinforcement; (4) traction by lateral strips of adhesive laid along the adjacent finger, the end of the adhesive being drawn over the edge of a palmar splint; this is necessary only in cases with much overlapping (Fig. 342, *a*).

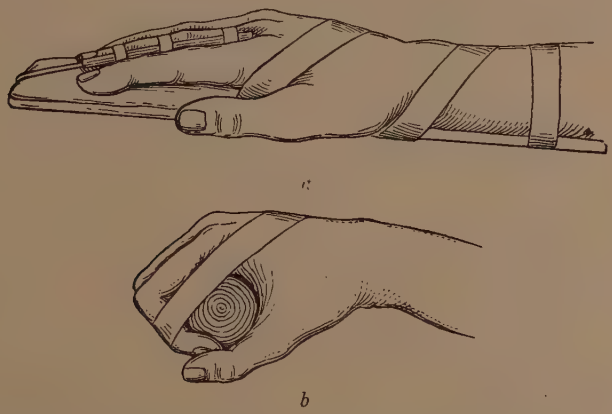


Fig. 342.—Two methods of treatment for fracture of a metacarpal or phalanx: *a*, Adhesive traction straps fastened to margin of finger and brought over the end and fastened to the bottom of a splint. Note countertraction by adhesive passing spirally around palm and wrist; *b*, bandage or wooden cylinder clenched in palm and held there by adhesive.

Results.—Union is generally complete in three weeks. Some bony thickening and stiffness is invariably present at first; much or all of this usually disappears after a few months and the final functional outcome is good. Sometimes inflammation of the bone occurs as an early complication.

Disability.—Total, three to five weeks; partial, two to four weeks.

Finger Fractures

These commonly occur in the segments nearest the knuckles, and they are due almost always to direct violence and often are compound (open) fractures, as in run-over and machinery accidents.

Symptoms.—*Deformity* from swelling and displacement varies, being most marked near the articulation. Crepitus, false motion, and local pain on direct or indirect pressure exist, and irregularity may often be felt (Fig. 343).

Treatment.—*Reduction* is generally easy by traction and flexion. *Splintage* by a molded plaster-of-Paris or padded wooden or hairpin

Fig. 343.—Fracture-dislocation of the last joint of thumb.

splint is usually efficient. In some cases bending the fingers into the palm is a better procedure (Figs. 344, 345).

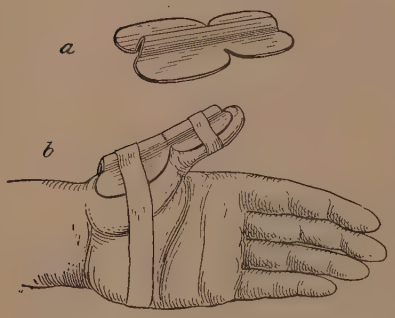


Fig. 344.—*a*, Aluminum or tin shoehorn splint for fracture of a thumb metacarpal or phalanx; *b*, splint applied to maintain abduction.

Fig. 345.—Hairpin splint for a fracture-dislocation or sprain of a finger.

Results.—Union is complete in three weeks and is generally firm. The nearer the joint, the less likely a perfect result, and then some permanent swelling and stiffness is often to be expected.

Pelvis Fractures

This includes fracture involving the *entire pelvis* or any of the three bones composing it, namely, the *ilium*, *ischium*, and *os pubis*. These bones are rarely broken except from extreme forms of violence,

like high falls, run-over and crushing accidents, and frequently the associated visceral and blood-vessel injury results in fatality. Clinically there are two divisions: (1) With intrapelvic injury; (2) without intrapelvic injury.

Anatomy and Landmarks.—*Anterior Iliac Spine.*—Often visible and always palpable as a sharp or rounded prominence.

Posterior Iliac Spine.—At the rear end of the iliac crest and often quite prominent.

Iliac Crest or Ala.—Visible and palpable along much of the margin.

Pubic Symphysis.—Sometimes visible at the inner lower margins of the iliac crest, and usually it can be spanned between the fingers.

Pubic Spines.—Visible sometimes, and they can generally be felt at each end of the symphysis.

Ischial Tuberosity.—Visible sometimes and usually palpable at the margin of the internatal folds, and it always can be felt rectally and vaginally.

Ischial Ramus.—Palpable through the rectum and vagina.

FRACTURES WITH INTRAPELVIC INJURY

These involve the so-called "ring of the pelvis," with more or less damage to the *bladder*, *urethra*, and *blood-vessels;* less commonly the *intestines* may also be affected.

Causes.—*Direct violence* from heavy blows or crushes usually, as from falling objects, run-over and crushing accidents.

Indirect violence transmitted from the hip or thigh is a much less common origin.

Varieties and Sites.—These depend upon the manner of the accident and place of its receipt. Force inflicted from side to side is likely to involve the crest of the ilium and pubic ramus on the same or opposite sides; from before backward, the horizontal and descending pubic rami suffer mainly. In younger patients, the fracturing may be through all or some of the three developmental lines. Figure 346 shows the commonest locations; the *pubis* is most often broken, next the *ilium*, and the *ischium* very rarely. Displacement is ordinarily not marked.

Symptoms.—*Disability* is generally instant and complete from pain, deformity, and shock.

Deformity may show by swelling and ecchymosis over the seat of injury, and the anterior spine or iliac crest may show mal-alignment. *Crepitus*, *motility*, and *local pain* can often be elicited; pain transmitted by lateral pressure over the buttocks or through the thigh is very

suggestive. *Rectal* or *vaginal examination* may give the best confirmation, as thereby the fragments or irregularity can often be felt. *x*-Ray examination is often of determinative value. A *pathognomonic sign* is ecchymosis along the perineum that often diffuses into the upper

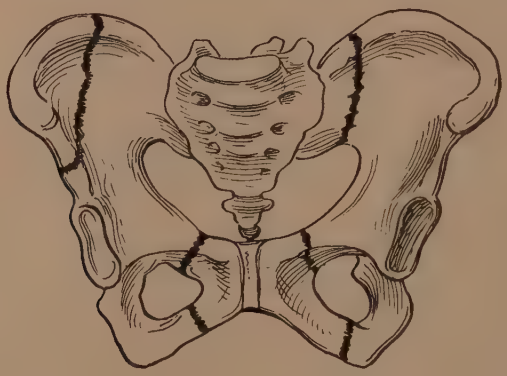


Fig. 346.—Usual sites of fracture of the pelvis.

inner thigh and over the scrotum; indeed, ecchymosis that appears late and which is located in a place distant from the site of impact is always suggestive of fracture in any part of the skeleton.

Urethral involvement may be indicated by bloody urine, dysuria, retention, or extravasation into the perineum, where it appears as a boggy swelling; the membranous portion is most often affected and it may be torn across, punctured, or pressed upon by bone or effused blood. Later the scrotum or labiæ may be much swollen.

Fig. 347.—Rupture of bladder and deep urethra; the black areas indicate zones into which urine may extravasate.

Bladder involvement is generally intraperitoneal and can be determined by the passage of bloody urine or by retention; careful cystoscopic examination is valuable. The usual test of filling the bladder with a known quantity of sterile solution, and then withdrawing and measuring it, is dangerous. The extent of tearing varies from a small hole to an extensive rent. Urinary tract involvement is most often seen with pubic fractures (Fig. 347).

Blood-vessels, like the iliac, pubic, obturator, and gluteal, may be torn or bruised, leading to hemorrhage or thrombosis and embolism.

Treatment.—*Shock* is given the usual attention.

Urinary tract damage treatment depends upon its extent. If extravasation from the urethra into the perineal region occurs and a catheter cannot be passed after a few *cautious* trials, an external urethrotomy is performed and the torn urethra stitched at once; or, better, a drainage-tube is inserted into the bladder and repair made later if the opening does not spontaneously close. Usually it is an extremely difficult matter to identify a torn urethra after such an injury as the tearing of the soft parts, and the clotted and fresh blood effectually obscure the field.

Bladder damage requires opening of the abdomen and layer suture of the opening if it be not too large; otherwise it is sewed about a drainage-tube having exit suprapubically. In any event, drainage of the skin incision must be provided to prevent subsequent breaking down of the wound with fistulous formation.

Blood-vessels require attention only if intra-abdominal hemorrhage seems apparent; then laparotomy is done.

Intestinal involvement shows by early rigidity of the abdomen, tympanites, and pain; vomiting and other signs of peritonitis may follow. Early laparotomy is indicated for suture or anastomosis.

Bony damage rarely calls for or permits setting unless it is to reduce a broken crest or ramus, which sometimes allows of replacement by pressure or manipulation and subsequent retention by pads and adhesive. Ordinarily all that can or need be done is to apply wide bands of adhesive about the entire pelvis, with a bandage about the straight or pillowed slightly flexed knees. In some cases a single or double plaster-of-Paris spica reaching from below the knees to the umbilicus may better immobilize. This is worn until loose and replaced as often as needed for six to eight weeks.

Occasionally a laced harness of canvas or moleskin made like "tights" is very effective.

General care to prevent sepsis and hypostatic changes is imperative. Urinary antiseptics, like urotropin, are advisable.

Results.—These are often serious cases from the start and quite difficult to handle. If *sepsis* or *peritonitis* does not follow within the first week, it is not likely to occur or be serious, as it is then generally limited to a *cystitis*, to be treated in the usual manner. *Urethral* and *bladder drainage* may be necessary for a month or six weeks, and thereafter any *sinus*, *fistula*, or *stricture* receives the appropriate treatment.

Sexual power may for a time be diminished or lost; it is practically always restored. *Deformity* may persist in the pelvic outline, and rarely it may result in a limp or other defect in extreme cases.

FRACTURES WITHOUT INTRAPELVIC INJURY

Ilium Fracture.—*Anterior spine* may be broken by a direct blow occasionally; less often muscular force is responsible. In one such case seen by me it occurred in a boy while doing the hop, skip, and jump.

Symptoms and Treatment.—The detached fragment is usually visible and always palpable. It is sometimes replaceable by relaxing the thigh muscles and then is held by a pad and adhesive.

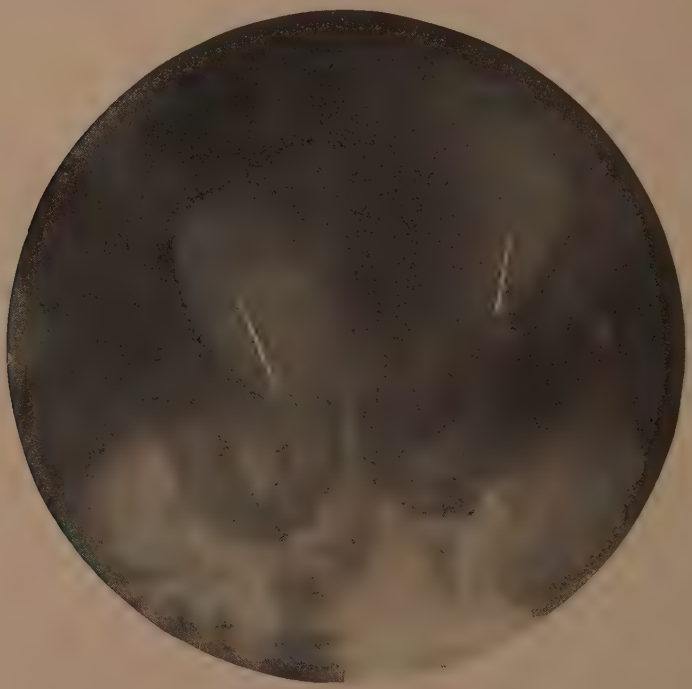


Fig. 348.—Fracture of rami of pubis and ischium (bilateral). Treatment indicated: extension and adduction of limbs; double plaster-of-Paris spica reaching from unbilicus to below knees; remove same in six weeks.

Union results with perfect function in four to six weeks; this may be fibrous and otherwise incomplete, but is of no consequence, because the expanse of Poupart's ligament will not allow much motion.

Crest or **ala** may be broken along the margin or splits may radiate centrally.

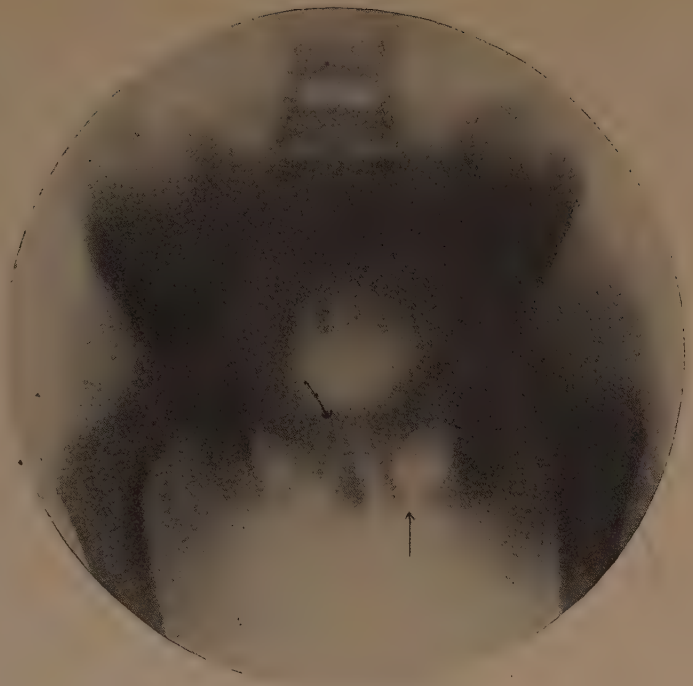


Fig. 349.—Bilateral fracture of the pelvis involving the rami of each ischium and pubis.

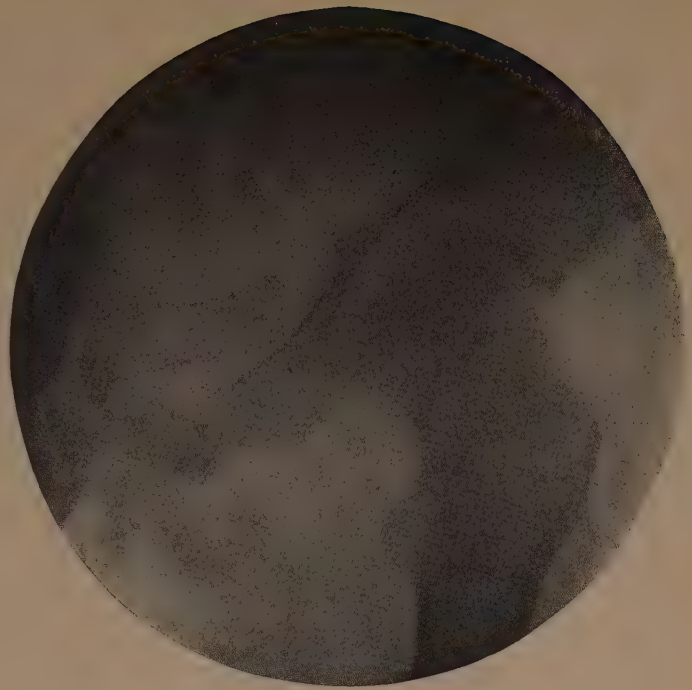


Fig. 350.—Fracture of the ramus of the pubis and ischium. The fracture site is quite typical, but the extent of the separation is rather extreme. Treatment indicated: double plaster-of-Paris spica reaching from the umbilicus to below *each* knee.

Symptoms and Treatment.—*Disability* is generally complete and immediate. *Deformity* may show by swelling and mal-alignment. Crepitus, false motion, and local pain exist together or separately; displacement is not marked. *Immobilization* by an adhesive swathe, with the bent knee tied to a pillow, is usually efficient.

Results.—Union occurs early and after three weeks is usually complete, with gradual perfect restoration.

PUBIS FRACTURE

Ramus involvement is the commonest, but even this is extremely rare as an isolated occurrence (Figs. 348–350).

Symptoms, treatment, and **results** are similar to the preceding.

ISCHIUM FRACTURES

This bone is very rarely broken alone, and but 6 such authenticated cases are reported by Malgaigne.

Symptoms, treatment, and **results** are like the preceding.

ACETABULUM FRACTURES

This is rarely broken except as an associate of other fractures. Recently some cases of depressed comminuted fractures of the floor have been reported.

Varieties affecting the *rim* and *floor* are described (Fig. 351).

Fig. 351.—Lines of fracture of the acetabulum.

Causes.—Generally extreme forms of violence applied to the hips or thighs are responsible; very rarely *direct injury* is the source.

Symptoms.—Usually a dislocation of the hip or fractured neck of the femur is suspected until *x*-ray examination makes the differentiation.

Disability is instant and complete.

Deformity is seen in swelling and changes in the attitude of the patient and the limb. *Crepitus* may be elicited on rotation. *Local pain* from pressure over the hips and upon the thigh is present. *Shortening* may exist in fractures of the floor of the acetabulum.

Treatment.—*Setting* is uncalled for except in floor cases with impaction of the head through the depressed comminution; here traction under anesthesia may be tried. Later treatment is *immobilization* by some form of

extension apparatus or a plaster-of-Paris hip spica. *Rim* fracture needs only adhesive swathing or a plaster-of-Paris spica.

Results.—*Rim* cases recover completely and union is firm in four weeks. *Floor* cases generally have persistent stiffness of the hip and perhaps some shortening and limp. However, Stimson relates and illustrates a case reported by Moore in which a fractured neck of the femur was suspected and the man was able to walk with but a slight limp; several years later autopsy showed "the injury to have been a fracture of the pubis, ilium, and acetabulum, with deep displacement inward of the head of the femur."

SUMMARY OF PELVIS FRACTURES

In the absence of *intrapelvic damage* they do well, and working capacity is usually restored within two or three months.

The *pubis* and *ilium* are most likely to be involved.

When intrapelvic damage exists, the outlook is doubtful for the first week; but if sepsis or peritonitis does not develop by that time, the prognosis becomes that of cystitis, or a urinary fistula, sinus, or stricture, and while these may be tedious and annoying, danger to life is inconsiderable.

The *bones* knit usually before the complications get well and the remaining deformity rarely disables, although it may be quite apparent externally or in *x*-ray views. Working capacity may be restored in three months; or with active complications disability may last longer.

FRACTURE OF THE FEMUR

This is a relatively common injury, and in my list comprised 154 cases, a percentage of 3.5. Of these, 40 per cent. involved the *neck* of the bone.

Anatomy and Landmarks.—UPPER END.—*Great trochanter:* Can be seen often and generally is readily felt. *Fascia lata:* Tension of it is usually firm, but is changed in fractures. *Scarpa's triangle* The normal feel is altered in certain fractures. *Inguinal fold:* Axis changed in some fractures. *Shaft:* Partly palpable sometimes.

LOWER END.—*Condyles:* Rather prominent and often can be seen, and always are palpable, especially the internal. *Popliteal notch:* Hollowed and sometimes allows direct palpation of bone beneath.

UPPER END FRACTURES

Neck Fracture

This is the "fracture of the hip" so common in persons over forty-five years old; in those over seventy it comprises about three-fourths of all fractures at that age, the rest being practically Colles'. It is more common in young persons than was suspected before the advent of *x*-rays, and in them is relatively more frequent than epiphyseal separation.

Causes.—Age changes in the bone due to osteoporosis is the determining cause more than alteration in the axis of the neck in the aged; the normal angle of the neck to the shaft is about 130 degrees. Cotton aptly states that old people do not so well know "how to break a fall." This osseous senile change generally begins about fifty. *Indirect violence* usually is the source, and this is transmitted from the hip, knee, or foot, due to a trip or fall or twist, often inconsiderable in extent.

Fig. 352.—Upper end of femur and usual lines of fracture.

Direct injury is a rare source of origin.

In the aged, women are more prone than men, and the younger the patient, the greater the necessary violence.

Lines of breakage are transverse, oblique, vertical, comminuted, or impacted.

Varieties and Sites.—*The Two Main Forms* (Fig. 352).—(1) *Through the neck;* also called *intracapsular* or *subcapital* (Kocher). Here the break is close to the head or inside the path of the spiral line in front, or the intertrochanteric line behind. This type is rather more common after sixty years of age. The periosteum is generally greatly torn, and hence vitality is likely to be seriously involved, and this is the element that is so important in the outcome. Impaction is infrequent, but as the nutriment to the head comes through the ligamentum teres, bony union is very unlikely, and only 14 cases of osseous union in this form are recorded (Keen). In the usual unimpacted cases there is little or no displacement.

(2) *At the base of the neck;* also called *extracapsular* or *intertrochanteric* (Kocher). Here the break is at the outer end of the neck, and usually it follows the spiral line behind as it passes between the trochanters; in other words, cleavage is at the junction of the neck

and shaft. Deflecting lines of breakage may detach the lesser trochanter, or more often split into or separate the great trochanter or even radiate to the shaft.

"The common fracture is that in which the neck is bent backward with crushing of the posterior part or penetration of the neck into the trochanter" (Stimson).

The periosteum is less seriously involved in this form of fracture, and hence vitality is not greatly affected and the chances of bony union are better, especially as *impaction* is more likely; hence the initial handling of these patients should be directed toward keeping

Fig. 353.—Fracture of neck of femur (intracapsular). Note also avulsion of lesser trochanter. Treatment indicated: extension and plaster-of-Paris spica with limb in wide abduction.

the impaction unseparated. The extent of this enmeshing of fragments varies; in extensive splits or comminution it may be quite complete. When there is little or no impaction, there is more upriding of the shaft and hence shortening occurs. Where (rarely) the anterior portion of the neck shows penetration, a position of *inversion* occurs.

Formerly it was considered important to determine whether the fracture was *through the neck* (intracapsular) or at the *base of the neck* (extracapsular), but now clinical regard is more for the presence or absence of impaction, and this is usually demonstrable in terms of shortening; if much exists, the chances of impaction are remote (Fig. 353).

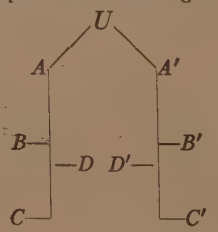
Symptoms.—*Disability* is almost invariable, instant, and complete; in some few impacted cases the patient has been able to stand or walk short distances with much difficulty. *Deformity* is usually typical, and visibly shows by: (*a*) *Eversion*, so that the foot is outwardly rotated and may rest on the whole outer margin of the sole; the outer edge of the bent knee is also visibly mal-aligned in flexion, and, indeed, this outward tilt or external rotation involves the whole limb. *Inversion* is a rarer finding. (*b*) *Shortening* is apparent, especially when the limbs lie close together, and then the drawing up at the foot, ankle, and knee shows markedly; it is most prominent in *unimpacted* cases and those *through the base of the neck* (extracapsular). The average amount is over an inch and it may be more; in many untreated cases it increases within the first week. (*c*) *Inguinal* and *gluteal folds* are higher and more vertical and internal. (*d*) *Swelling* and *ecchymosis*

Fig. 354.—Landmarks for measurements of the lower extremities: *A*, *A'*, Right and left anterior superior spine of ilium; *B*, *B'*, right and left internal condyle of femur; *C*, *C'*, right and left internal malleolus tip; *D*, *D'*, right and left patella tubercle; *U*, umbilicus.

For notation or history purposes the findings may be listed thus:

$U\,C =$	$U\,C' =$
$A\,C =$	$A'\,C' =$
$A\,B =$	$A'\,B' =$
$U\,D =$	$U\,D' =$
$A\,D =$	$A'\,D' =$
$B\,C =$	$B'\,C' =$

In a graphic form this diagram may be used:



are usually late in appearance and appear chiefly in the inguinal, gluteal, and upper shaft regions. *Palpation* elicits (*e*) *elevation of the trochanter* corresponding to the shortening. (*f*) *Fulness* in the upper outer part of Scarpa's triangle; very suggestive where other signs are not prominent. (*g*) *Fascia lata* relaxed on the outer side. (*h*) *Crepitus* should be sought for very carefully by placing one hand over the trochanter and slightly rotating the limb; it only can or should be demonstrated in unimpacted cases. (*i*) *False motion* should also be sought for by the same means as the preceding, and it appears in the same class of cases. (*j*) *Active motion* is greatly diminished or lost, notably inversion and elevation of the limb or foot. (*k*) *Passive motion* is limited or lost, due to pain, deformity, and spasm of muscle.

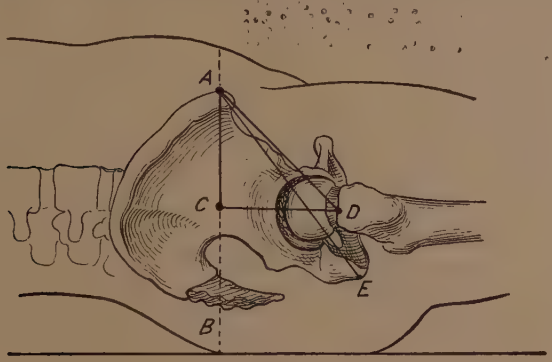


Fig. 355.—Topographic markings about the hip-joint: *A–B*, Perpendicular line dropped from anterior superior spine (*A*) to the table (*B*) with patient supine; *A–D*, line joining anterior superior spine and top of great trochanter (*D*); *A–E*, line joining anterior superior spine to tuberosity of ischium; *C–D*, line drawn vertically upward from great trochanter. *Nélaton's line* = *A–E*, normally with the knee at an angle of about 45 degrees, the great trochanter touches this line. *Bryant's triangle* = *A–C–D*.

Measurement.—(1) From the anterior spine of the ilium to the internal malleolus there will be shortening; the same will appear from (2) the anterior spine to the internal condyle (Fig. 354). Measurement from (3) *umbilicus* or (4) *teeth* to the internal malleolus is less valuable because of the intervening soft parts and respiratory movements; (5) Bryant's triangle and (6) Nélaton's line measurements afford confirmatory signs (Fig. 355).

There is a *normal difference* in the length of the limbs, amounting to between $\frac{1}{8}$ and $\frac{3}{4}$ inch or over, and this must be taken into account in some cases.

Treatment.—*Primary care* in the transportation of such patients is very important and may determine the outcome. Temporary or

improvised extension may be used as shown in Fig. 356. The limb should be kept at rest between pillows or padded sand-bags or bricks; or a long side splint made of padded thin board is used, reaching from the axilla to below the sole, and held to the chest, hips, and lower limb (Fig. 357). It must be wide enough to allow its edge to rest on the bed, and turns must be taken over the foot to prevent rotatory changes.

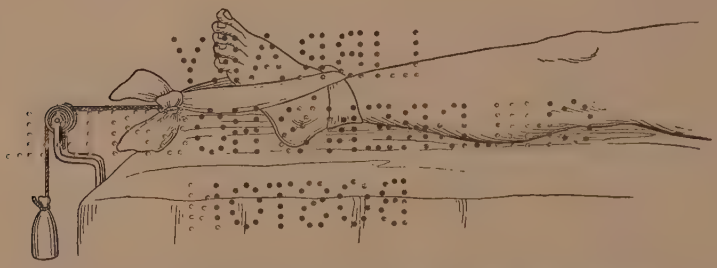


Fig. 356.—Towel or bandage tractor for temporary or improvised extension of the lower extremity.

In old people it is needful to elevate the head of the bed from the first to forestall hypostatic complications; this and the general treatment can be aided by placing wide boards (like the household ironing-board) transversely under the mattress so that they rest on the bed-frame beneath the shoulders, hips, and knees (Fig. 357).

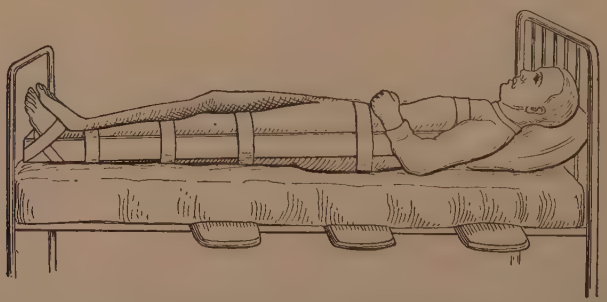


Fig. 357.—Long wooden side splint in fracture of the femur. Note "ironing-boards" under mattress to prevent sagging.

In all cases much attention is given the *general condition* and the comfort of the patient must be a main item. Good nursing is essential. Fresh air and liberal feeding and tonics are of much value. Treatment details vary, depending upon the age and condition of the patient and the presence or absence of *impaction*.

Old patients who are "fussy," feeble, or suffering from bronchial, cardionephritic, arterial, or allied ailments will probably die within a

few weeks if subjected to absolute recumbency and immobilizing dressings; hence treatment here must be of the *patient* rather than of the *bone*.

If rest in bed with supports from (*a*) sand-bags at hip and on each side of knee and ankle, or from a (*b*) long side splint is irksome or enfeebling, then the patient must be allowed to get out of bed, assuming whatever position is comfortable. If, however, general conditions are better, the (*c*) *side splint* and some *extension* (not over 20 pounds is needed) may be used for three or four weeks. Then (*d*) plaster-of-Paris spicas may be used and the patient allowed up in a chair. In selected *impacted* cases the immediate use of this plaster spica is often the best treatment. In some rugged old people management may be on the plans suggested further.

Other Methods of Treatment.—(1) *Continuous traction*, applied by aid of a long side splint and a **T** foot-piece, the weights (10 to 30 pounds) being hung over a pulley at the foot of the bed, a cord being attached to straps of adhesive applying a pull directed from above the knee. This may be a typical Buck's extension apparatus and a Volkmann's track, or the limb may rest in a cradled splint (like Hodgen's) suspended by a support reaching over the bed. Pressure over the trochanter by pads or encircling bands may also be included. (2) *Abduction*, as advocated mainly by Whitman. Here the patient is anesthetized and the hips are placed on a pelvic rest and both limbs abducted to the normal limit, shortening being overcome by traction; overcoming impaction by flexion if it exists. Soft bandages and plentiful cotton padding are then placed, and a plaster-of-Paris spica reaching from the toes to the axilla is then applied, great care being taken to keep the limb abducted to the same degree as normally possible in the uninjured limb (Fig. 370). With this spica in use the patient can be turned on the face or otherwise moved without disturbing the alignment. In two months the upper half of the dressing is removed, the rest a few weeks later. Thereafter the thigh is abducted daily and walking is allowed, preferably at first by the aid of a Thomas-Ridlon hip splint (Fig. 358). Excellent results are claimed, especially in rugged and young patients. (3) *Splints* of metal, like the Thomas or Ridlon, with or without traction and pressure over the trochanter. The so-called "ambulatory splints" seem irrational in this fracture, of all places. (4) *Operation* by direct open exposure for reduction and fixation by a metal nail or long bone pin driven into the head of the bone. This is most applicable in sturdy people and in some cases of non-union (Fig. 359).

In some unimpacted cases Cotton advises placing a heavy pad over the trochanter and then with blows of a broad wooden mallet

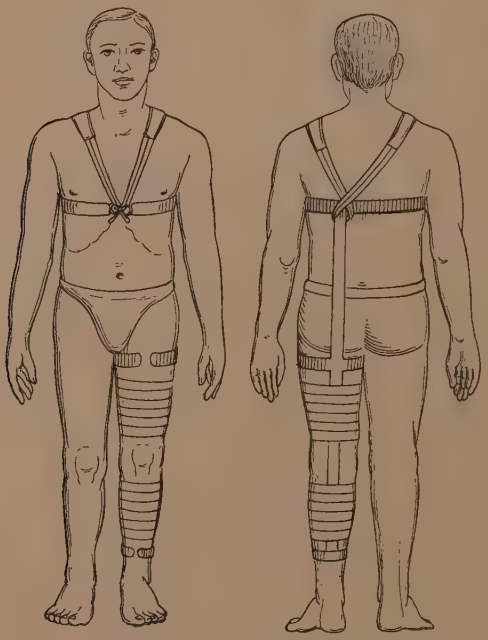


Fig. 358.—Thomas-Ridlon hip splint.

making an attempt to jamb the parts together—in effect, an effort to deliberately cause impaction. I have never resorted to this, but it appears rational and worthy of trial, especially in that class of cases where traction overcomes shortening readily.

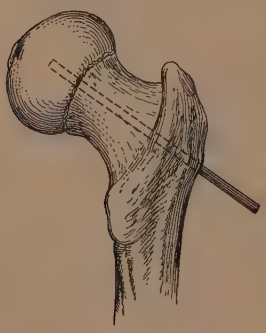


Fig. 359.—Bone peg or metal spike in fractured neck of femur.

Differential Diagnosis.—Dislocation of the hip of the forward type is the only likely error. This is exceedingly rare, as the deformity is different, the head of the bone can be felt to rotate, the disability is less extreme, and the patients are younger.

Complications.—*Pneumonia* is very common, and if it occurs early may be lobar or bronchial in type; commonly it is hypostatic, with few symptoms aside from slight cough and some fever, but with a great deal of torpor, ending with a low-grade delirium and deepening coma. It is best guarded against by elevating the bed and allowing such changes in posture as are pos-

sible; enforced deep breathing and dumb-bell exercises with the arms are also valuable.

Delirium tremens is usually fatal; apparently it is less common than with other fractures, perhaps because the patients are less actively alcoholic.

Bed-sores from decubitus are rather common. Smooth sheets, changes in position, air cushions, "rings," and alcohol spongings are the main preventives.

Fig. 360.—Fracture of neck of femur—end-result, showing good bony union with little shortening.

Shock is often a primary incident, and in the aged and depleted may be rapidly fatal.

Results.—Most fatalities occur in the first week from the causes previously named, and patients surviving this period generally go on to some sort of recovery.

Union is rarely bony in *fracture through the neck*, and in this form the head of the bone may occasionally fail to unite even by fibrous tissue. In fracture at the *base of the neck*, bony union should at least

be sought even in the aged, and in many cases will be attained; in this locality there may be a production of new bone outside the fracture line to such a degree that interlocking results despite failure of bony union at the actual line of breakage.

Three months at least is necessary for union of any sort to be strong enough to permit weight bearing; and for a year care is needed in using the limb (Fig. 360).

Deformity and *disability* of some sort or degree usually persists and may be in the nature of (*a*) *Shortening:* This varies from ½ inch to 3 inches. (*b*) *Limitation of motion:* In the hip, notably as to flexion, internal rotation, and abduction; there may be limitation enough to amount to virtual ankylosis. The associated stiffness of the *knee* and *ankle* is

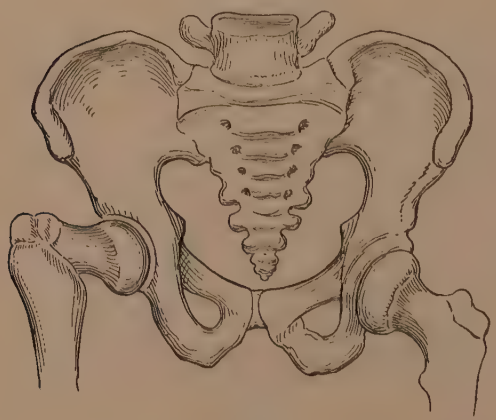


Fig. 361.

Fig. 362.

Figs. 361, 362.—Coxa vara following fractured neck of femur.

due to disuse and is remediable generally. (*c*) *Limp* depends upon the two preceding, but it varies with the adaptability of the patient to changed conditions; the stiffness at the hip is often a greater factor than shortening in causing a halting gait and need for a cane or crutch. (*d*) *Atrophy* is mainly due to disuse, and most or all of it is recovered from after a time. (*e*) *Eversion* may to a great extent be overcome and is variable in degree. (*f*) *Coxa vara traumatica* (Sprengel) is an occasional change in the angle between the shaft and the neck, so that instead of being about 130 degrees it approaches that of a right angle. It occurs most frequently in younger persons and sometimes it follows too early use of the limb; good results follow operation for its relief (Figs. 361, 362).

Summary of Neck of Femur Fractures.—*Any disabling or deforming injury to the hip in a person over forty-five should be regarded as a fracture until proof to the contrary is forthcoming.* Sufficient for *diagnosis* are: (*a*) *Disability* as to rotatory power and capacity to raise the heel off the bed without lifting the thigh; limited rotatory function of hip. (*b*) *Deformity* indicated by eversion or changed level of the trochanter or the inguinal fold. (*c*) *Fulness* and resistance felt in the upper part of Scarpa's triangle. (*d*) *Fascia lata* relaxation.

Impacted cases (usually those showing lesser amounts of shortening and eversion) are handled with great care, and the interlocking is interfered with only in that class of rugged patients who seem able to stand prolonged fixation.

The patient and not the bone is treated where physical resistance is ebbing. Cases with fibrous union often do surprisingly well with the aid of special shoes and supporting devices; considerable deformity with marked eversion and limp does not necessarily mean disability, especially in patients desirous of combating the inevitable.

Head of Femur Fractures

These are exceedingly rare, and only 3 cases are on record (Keen's Surgery).

Trochanter Fractures

Very few of these have been reported; not more than a dozen in all, according to Stimson. A modification of these, comprising a small number of cases, shows the line of fractures running from or near the junction of the neck and shaft to or through the great trochanter. The two divisions thus created have in the upper part, the head, neck, and upper part of the trochanter. All of these foregoing were clinically regarded and treated as fractured hips until disproved by *x*-rays or autopsy.

Subtrochanteric or diatrochanteric fractures are relatively common and in these the line of cleavage follows the spiral line, often separating the lesser trochanter completely. These fractures occur usually from some form of violence causing rotation of the trunk while the lower extermity is more or less fixed. The symptoms and treatment resemble shaft fractures (Figs. 363–365).

Fig 363.—Subtrochanteric fracture of the femur.

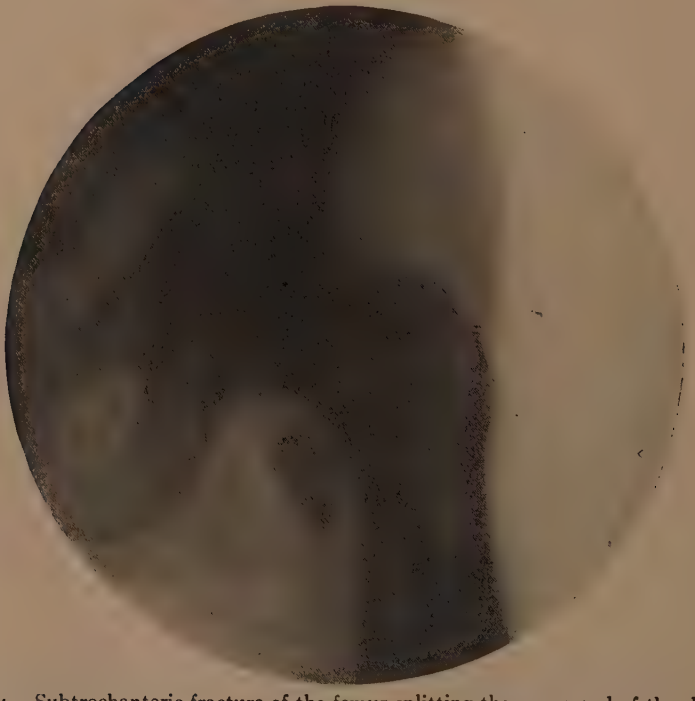


Fig. 364.—Subtrochanteric fracture of the femur splitting the upper end of the shaft and the lesser trochanter.

Fig. 365.—Fracture of upper end of femur due to cystic degeneration of bone. This patient had numerous fractures of the extremities, and most of the bones showed areas similar to those shown here.

Epiphyseal Separation

This also occurs infrequently, and is less common than true fracture at the same age.

Union takes place between the head and shaft between the seventeenth and twenty-first year, and hence the injury antedates this period of life.

Causes and Symptoms.—These are similar to fracture, and *x*-ray diagnosis is usually determinative. It is said that in some instances complete disability may not occur at once, but that weight bearing adds to the angulation of the neck, so that when the patient seeks relief, coxa vara already exists.

Treatment.—(1) Traction and extension by the methods named in the foregoing. (2) Abduction method of Whitman; this is especially valuable and is the best management for the average case. (3) Thomas' hip splint.

Whatever treatment is employed, the after-care demands that no weight bearing be attempted for at least four months, and thereafter some support is given for a year.

Results are excellent if reduction has been properly accomplished; otherwise coxa vara often occurs.

SHAFT OF FEMUR FRACTURE

This includes breakage from below the trochanters to above the condyles; fractures of the upper end of this area are sometimes known as *subtrochanteric*, those of the lower end as *supracondyloid*.

Causes.—*Direct violence* more often fractures the lower third, often producing a compound (open) break, and heavy blows from falling objects and jamming or run-over accidents are the main factors.

Indirect violence from falls on the feet or knees may result in spiral or incomplete lines of breakage. *Muscular violence* is a rather rare producing cause.

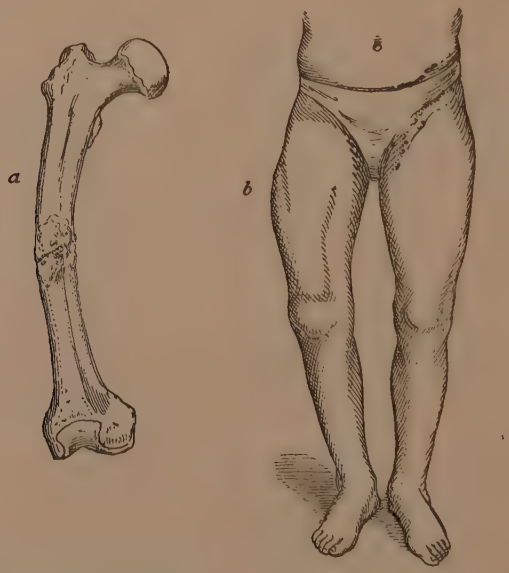


Fig. 366.—Fracture of the shaft of the femur: *a*, Union with outward bowing; *b*, external appearance.

Varieties and Sites.—Simple or compound, complete oblique fracture is the rule, the middle and lower third levels being the most usual sites. Spiral and incomplete (bending) forms also occur; the latter in children only, and in them transverse complete forms also appear.

Displacement is generally marked, the upper fragment being in front and external, more or less angulation also existing; the overlapping may amount to several inches from the drawing up of the lower fragment. Bony spikes not uncommonly penetrate the muscle and may even reach the skin; this is commonest in the lower third. Effusion into the knee-joint commonly occurs in the lower third forms, but

may appear in all; no adequate cause is known for this, but it has been ascribed to associated joint injury, extravasated blood, or venous stasis. It appears within the first few days, and is commonest in injury by indirect violence in children; in adults it slowly disappears, but in children it promptly subsides (Stimson) (Fig. 366).

Symptoms.—*Disability* is instant and complete. *Deformity* is generally marked, as the *shortening* and *tilting* is considerable; *swelling* and *ecchymosis* and *knee effusion* are later prominent. *Irregularity* generally cannot be felt through the muscles. *Mobility* is made apparent by placing one hand under and the other on top of the thigh and pushing one toward the other vertically or laterally; this may also elicit *crepitus* and *failure of rotation* of the trochanter.

Measurement verifies the shortening.

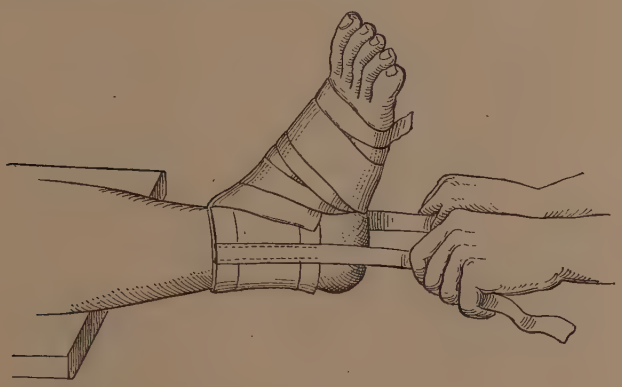


Fig. 367.—Traction straps for making extension of the lower extremity. Broad webbing is passed around the malleoli and to it are sewed heavy tapes. This can be used to attach weights or to secure the part to the foot-piece of the Hawley table.

Treatment.—The *first-aid care* must be carefully given in an effort to prevent compound (open) fracture. The limb should be straightened and kept thus by pillows, sand-bags, or padded bricks. A long side splint from the armpit to beyond the sole is very valuable; this may well be reinforced by another reaching internally from the perineum to the same distance as the preceding. The bed should be firm and kept thus by supports placed under the mattress.

Reduction is often extremely difficult and in most cases anesthesia is needed. It is often helpful to apply a weight to the limb to stretch the muscles for a day or more before anesthesia replacement is attempted in cases with marked displacement. Direct traction on the straight limb or with the knee bent is the usual maneuver; in some cases disengagement of the fragments can be brought about by press-

ure or flexion directly upon them. Traction is made by: (1) Holding the shoulders while pulling of the foot is steadily carried on. (2) Fixing the pelvis by a sheet passed about the groin and pulling on the foot by a bandage or sheet about the ankle and foot (Fig. 367). (3) Various forms of pulley or windlass devices. (4) Extension tables, of which Hawley's is the best.

The success of replacement is indicated by the disappearance of shortening, the presence of crepitus, and the straight alignment.

Splintage.—(1) With little shortening or deformity it is sufficient to apply direct traction (by any of the extension methods previously

Fig. 368.

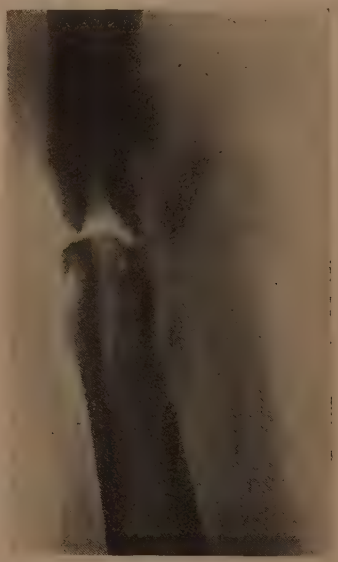


Fig. 369.

Figs. 368, 369.—Perfect reduction of a compound comminuted fracture of the femur (Hawley extension table used).

mentioned), maintaining it until displacement is overcome (usually two to four weeks), and this is then followed by a plaster-of-Paris spica from the toes to the axilla (Fig. 370). This is replaced if it becomes loose and is used six or eight weeks, and thereafter the limb is bandaged and allowed to bear weight in twelve weeks if union is firm and no pain or swelling occurs after guarded attempts at use. (2) *Buck's extension apparatus* with a pull varying from 10 to 40 pounds. (3) *Suspension splints* like Hodgen's. (4) *Suspension* and *traction splint:* This seems to combine the merits of all the devices, and is regarded by many as the method of choice. (5) *Double inclined plane* is generally only used early, especially in fractures near the knee. (6) *Transfixion* of the

Fig. 370.—Abduction plaster-of-Paris splint.

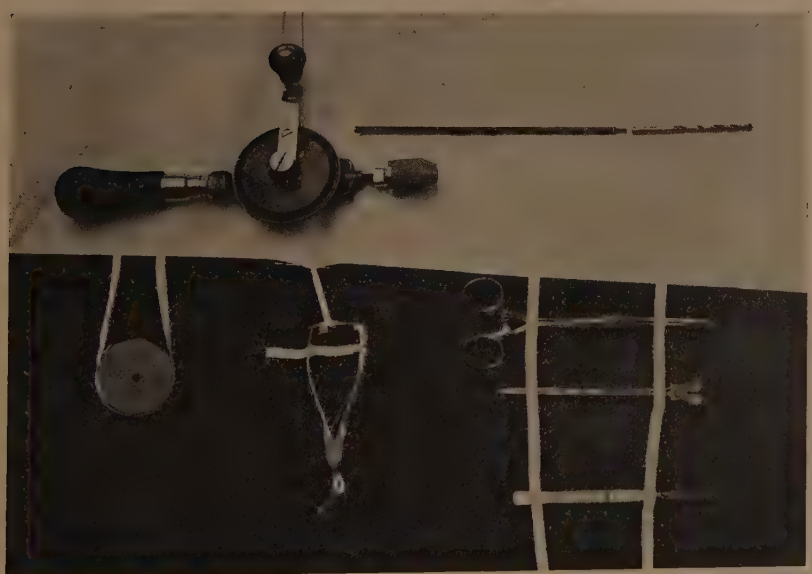


Fig. 371.—Instruments used in "transfixion treatment" of fractures. Upper row: "Yankee" brace and author's demountable drill; lower row: rubber disk to thread over drill ends; nasal speculum for use as retractor; artery clamp; director; scalpel.

PROPERTY OF SURGICAL OFFICE
NOT TO BE REMOVED

lower fragment by a nail or drill to which extension pulls are attached; this is the "Steinmann nail extension method." I have employed this in 21 patients, and regard it as an excellent procedure in selected cases (Figs. 371–373).

Operation to aid reduction may be needed, and suture or plating is frequently performed at the same time; these last are wisely reserved

Fig. 372.

Fig. 373.

Figs. 372, 373.—Fracture of lower third of femur in a fifteen-year-old boy. Treatment by transfixion. These radiographs were made six months after injury. Perfect result.

for very oblique, spiral, persistently displaced and mal-united cases. Open reduction and plating is an exceedingly formidable procedure and should not be undertaken by the inexperienced. Compound (open) cases are best cared for by some suspension method reinforced

by a metal bar which has a wide curve over the wound to allow change of dressings.

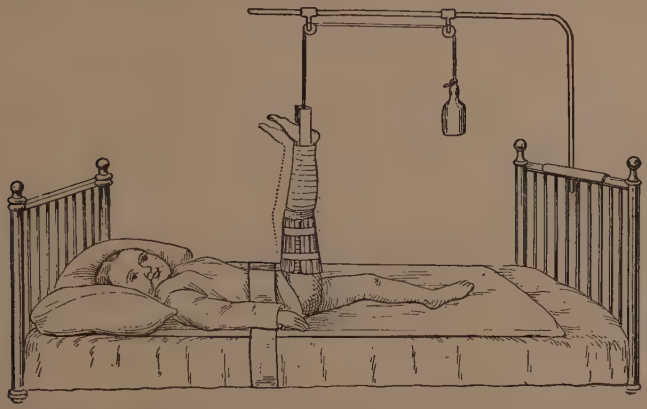


Fig. 374.—Suspension treatment of a fractured femur in a child. Both limbs are suspended in fractious children.

Fig 375.—Suspension applied in a two-year-old child.

Whatever method is used, special attention is given to counteracting shortening, angulation, and adduction by using traction, elevation, and abduction positions respectively.

Fig. 376.

Fig. 377.

Fig. 378.

Fig. 379.

Figs. 376–379.—Supracondyloid fracture of femur before and after Steinmann-Codivilla nail extension. Patient pinned between trolley car bumpers. (Case of M. G., Post-Graduate Hospital.)

The general condition of the patient receives appropriate management just as in fractures of the hip-joint.

In *children*, especially those under six, *vertical suspension* (Schede) of both legs, so that the limbs are at right angles to the abdomen, is the best non-operative method (Figs. 374, 375). The hips are raised just high enough off the bed to allow folded diapers to be inserted and extreme care is taken to prevent excoriation from pressure, urine, and feces.

Fig. 380.—Supracondyloid fracture of each femur. Note the marked eversion, knee-flexion, and shortening.

For older children, some preliminary extension and plaster of Paris is satisfactory. *Union* in children is usually solid enough within six or eight weeks to allow weight bearing in a plaster-of-Paris spica or a Thomas or other splint.

LOWER END OF FEMUR FRACTURES

These include *supracondyloid* forms, splitting of the condyles (*intercondyloid*); breaking one condyle (*condyloid*), or separating the epiphysis (*epiphyseal*).

Supracondyloid fracture occurs anywhere within the lower 6 inches of the shaft. The deformity resembles that of the below described

form, and in effect is that of a massive synovitis, plus a bent, angulated, everted, and completely disabled extremity. The pull of the gastrocnemius group tilts the lower fragment backward and often fills up the concave popliteal space by a bony convexity. I regard this as one of the most difficult fractures to successfully treat (Figs. 380–382).

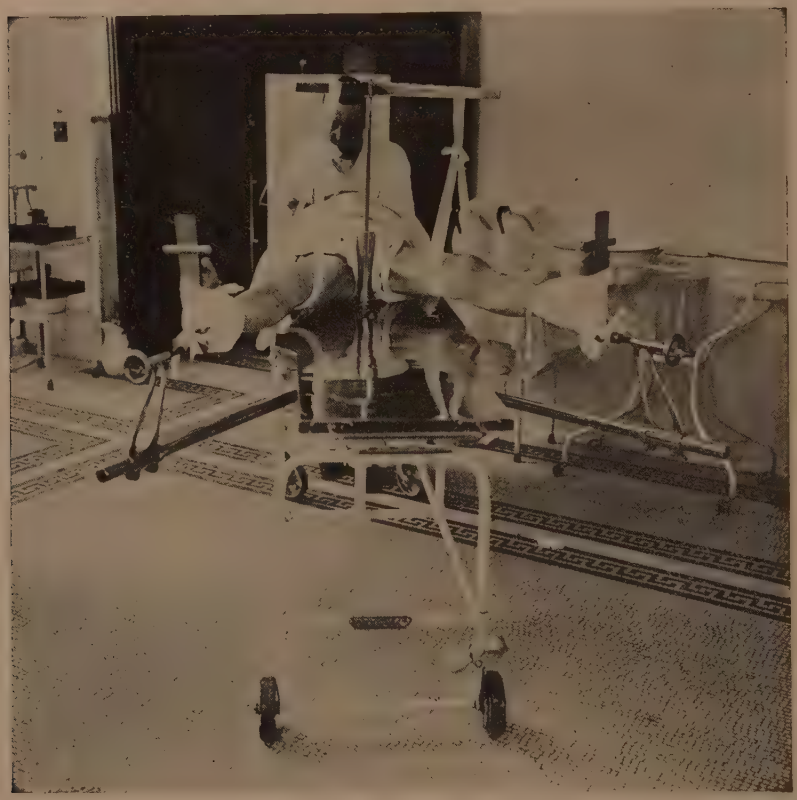


Fig. 381.—Supracondyloid fracture of each femur. Patient on Hawley table, limbs in extension and abduction; deformity corrected.

Intercondyloid Fracture

These lines follow the notch between the condyles, and the cleavage is generally more or less **T**- or **Y**-shaped. The degree of separation varies; it may be wide enough to allow the patella to sink into it. Displacement is generally extensive and the shaft overrides in front and spikes of bone often penetrate the muscles or skin; hence compound (open) fracture is common. The knee-joint is generally involved and always swells, and the popliteal vessels are sometimes bruised or torn (Figs. 383, 384).

Fig. 382.—Supracondyloid fracture of each femur. Further extension, and table top lowered to allow application of double plaster-of-Paris spica from toes to umbilicus.

Fig. 383.—Fracture of the internal condyle of the femur.

Fig. 384.—Fracture of the posterior portion of the condyles of the femur.

Symptoms.—*Disability* is instant and complete. *Deformity* is marked and is shown by *swelling* of the bent knee and variable *dis-*

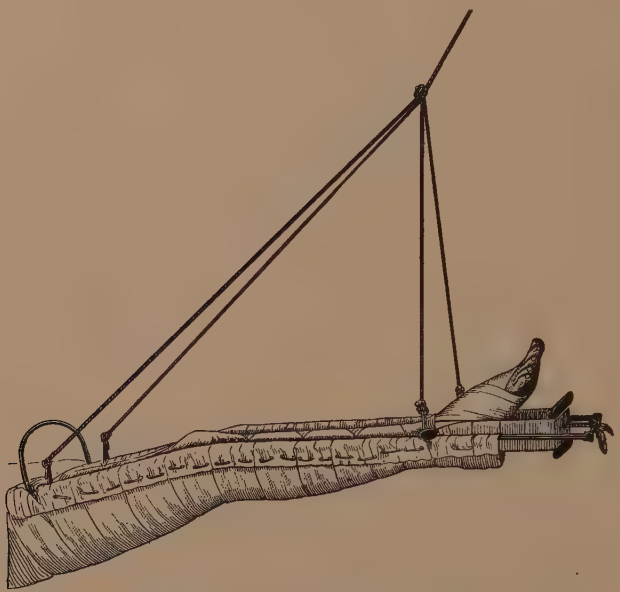


Fig. 385.—Hodgen's splint ("American Text-book of Surgery").

tortion and *shortening*. *False motion*, *crepitus*, and actual outlining of the fragments may be possible. *Measurement* discloses the amount

Fig. 386.—Rainey's tripod splint for femur fracture; anterior and posterior view.

of vertical displacement. The patella frequently occupies an abnormal and more or less fixed position. *x*-Ray examination is advisable.

Treatment.—*Reduction* even with anesthesia may be exceedingly

difficult and perhaps impossible without operation. Traction on the flexed or rotated knee is the usual manipulation, and setting is known to have succeeded when crepitus is felt and measurement shows relief from shortening. A great deal of traction is often needed and may be aided by weight extension applied for several days before actual reduction is attempted.

Splintage.—(1) *Double inclined plane*, most useful where the displacement is not great. (2) *Hodgen's splint*, the usual method (Fig. 385). (3) *Plaster-of-Paris splint*, when the setting is easily accomplished, is the best form of retention; the cast reaches from the toes to above the pelvis. It may also be used as a final stage of treatment after four or five weeks of other splintage. (4) Transfixion of the lower fragment by a nail or drill; if this cannot be done, the transfixion may be made through the head of the tibia. (5) The Rainey splint (Fig. 386). (6) Operative reduction and suture or plating may be needed.

Condyloid Fracture

This is a rare form, and confirmation is generally made by the *x*-ray, thus disproving an entertained diagnosis of sprain, synovitis, or ruptured ligaments. Separation is not likely to be marked. The internal condyle is oftenest involved.

Some of these cases fall into the class of so-called sprain-fracture.

Symptoms.—These resemble synovitis, with occasionally isolated crepitus and motility. Local pain and transverse broadening are relatively constant signs.

Treatment.—By manipulation and pressure reduction is accomplished, and then the limb is placed fully extended on a posterior and lateral splint, or encased in plaster of Paris, which is later split to prevent pressure. A position of moderate flexion is sometimes used also.

Within a month splints are removed and massage and gradual motion used, the knee being protected by a lighter posterior or encircling removable splint for four or five weeks longer. Walking begins when it does not produce great pain or re-effusion into the joint. *Internal epicondyle* fracture is a clinical curiosity.

Epiphyseal Separation

Union between the shaft and this largest of all the epiphyses occurs about the twenty-fifth year, and most cases of separation occur just before the twenty-first year. Separation here is second in order of

frequency to all forms, the upper end of the humerus being commonest (Poland).

Causes.—Usually some considerable twisting form of violence is necessary, and it is said to be quite typically produced by accidents in which the leg is caught and is forcibly hyperextended in the spokes of a vehicle or whirling machinery. The resultant displacement is generally forward or rotatory; rarely is it backward, and the knee-joint is commonly but little involved.

Symptoms.—These simulate a dislocation somewhat, and diagnosis is usually made by noting *deformity*, due to the swelling above and in front of the bent joint. *Motility:* The tibia partakes in this, and thus dislocation is ruled out. *Crepitus* inconstant—the so-called muffled or soft or cartilaginous sort. *Irregularity* or *malalignment:* Occasional. Compound (open) forms often occur in which the popliteal vessels are likely to be involved, leading to hemarthrosis, gangrene, or amputation. *x*-Ray examination is very valuable.

Treatment.—*Reduction* by direct traction and pressure, followed by gentle extension, is the usual manipulation. The procedure advocated by Reisman of making upward traction on the upper fragment by a strap about the limb is sometimes helpful. *Splintage* in full extension by plaster is usually the choice. This may be split at the end of a week; or if of the posterolateral type from the start, massage may be used.

After three or four weeks the original splints are removed, and then a lighter posterior or encircling dressing is used a few weeks longer. Use of the limb should begin in four or five weeks.

Irreducible and *compound* cases demand operative reduction, and often this may be quite difficult; very occasionally resection may be necessary. *Vessel damage* is corrected by ligature if the artery or vein is involved; if both are torn, immediate amputation to forestall inevitable gangrene should be done, assuming that vascular suture or anastomosis cannot be accomplished.

Results in Shaft and of Lower End Femur Fractures

Shaft cases almost always result in more or less *shortening*, and this varies between ½ inch and 2 or more inches. It may be associated with *rotatory* or *version* changes, so that the foot toes out or in. A great deal of it can be compensated for by a tilt of the pelvis, and while the limp and gait defect may be marked at first, in the end much or even all of it may disappear.

Excessive callus, *bowing*, and *overlapping* are most marked where

reduction has not been complete. The bony swelling may be irregular and painful at first, but later it grows smoother and painless.

Knee involvement may appear in the form of swelling and stiffness, and even for the first year a good deal of this may persist; later, under massage and forced usage, considerable improvement is to be expected. When right-angled flexion capacity is attained, there will be practically no disability for ordinary purposes, as this is the "physiologic limit of function" for the knee-joint.

Atrophy from disuse is overcome for the most part within a year; it is usually commensurate with the foregoing sequelæ.

Lower end cases may show remnants similar to the preceding, but the knee manifestations are commonly the most marked and persistent.

Patella Fractures

This sesamoid bone has attached to it, above, the strong quadriceps tendon, and beneath, the patellar tendon binds it to the tubercle of the tibia; laterally, there are ligamentous and fascial bands, and thus it is seen to have a very firm but elastic anchorage.

It is a fairly common fracture, and in my list occurred 61 times, a percentage of 1.2. It is analogous to fracture of the olecranon.

By some authorities the patella is regarded as a displaced portion of the tibial epiphysis.

Causes.—Men sustain the injury three times oftener than women.

Muscular violence is generally regarded as the more usual origin, and this generally takes the form of a sudden bending or twisting of the knee in an effort to regain balance to prevent falling after tripping or stumbling; or where some strong pushing force continues to overbend the knee with the limb more or less rigid. *Direct violence* in which the knee-pan is struck or impinges against an object is a less usual source.

In deciding the origin in a given case it must be remembered that quadriceps contraction may *produce* the fracture and *result* in the fall, and that the latter will often be looked upon as the *cause*, when, in reality, it is the *effect*.

Anatomically it is very difficult to fall directly on the knee-cap because the bending knee draws the patella upward, and the brunt of the weight is then received on the condyles or the head of the tibia.

Sites and Varieties.—The usual break is *complete* and more or less *transverse*, most commonly in the upper half of the bone; this is especially true where muscular force acts. *Comminuted*, *multiple*, and

more or less *vertical* lines of breakage are more often due to direct violence.

Separation of fragments varies, but usually they are apart enough to insert a finger-tip; the extent of the gap depends somewhat upon the initial degree of injury, and it may sometimes reach 3 inches or more.

In some cases there is splitting and more or less *incomplete* breakage.

A certain amount of rotation or angulation of the fragments may also occur, especially if the patient tries to arise unaided or otherwise further flexes the knee (Fig. 387).

Symptoms.—*Disability* is complete and instant from pain, effusion, and distortion. In some few cases, with little or no separation, patients have been known to limp short distances by keeping the knee perfectly straight, usually by walking backward. Voluntary extension is lost.

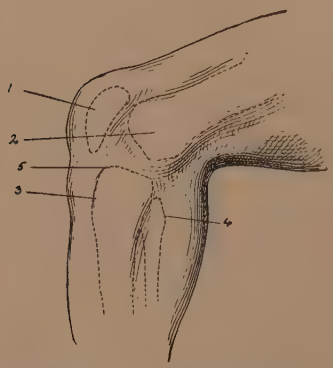


Fig. 387.—Bony prominence of the knee-joint: 1, Patella; 2, condyles of femur; 3, tubercle of tibia; 4, head of fibula; 5, head of tibia.

Deformity is seen in a uniform *swelling* of the joint and occasionally the distorted outline of the bone is apparent, but the first look at the swollen joint suggests synovitis. *False motion*, *irregularity* (depression or notching), and *crepitus* are usually felt, the latter especially where little separation exists.

Treatment.—*First aid* requires that the limb be kept straight and this can be done by sand-bags or a padded posterior splint. An ice-bag or lotions over the front of the joint may be added. *Reduction* is difficult until the pull of the quadriceps and the effusion decrease; the first is attained by full extension, the second by ice-bags or lotions and daily elastic bandaging of the joint from below up. After a week or ten days the intra-articular reaction will subside under these measures and further attention is then (*a*) non-operative or (*b*) operative.

(*a*) *Non-operative.*—Here the plan is to coapt the fragments, and whatever method is adopted, a posterior molded plaster-of-Paris, wire, tin, or wooden box splint is applied from the mid-thigh to the ankle. For the coaptation, *zinc oxid* adhesive straps are criss-crossed over the fragments in figure-of-8 fashion; or a series of them are applied and attached to the margins of the splint or to the limb. They must not

completely encircle the joint or in any manner obstruct circulation. These straps may be renewed if necessary, and at each reapplication the same care to obtain coaptation must be employed. Splintage is used four or six weeks, and after the first week massage will be of great value and should be used daily where possible. After this period the joint is encased in a split circular or, better, a posterolateral plaster-of-Paris cast and walking on crutches is allowed. After three or four weeks the cast is left off for increasing periods daily, strong admonitions being given not to overbend the joint. At the end of this period an elastic bandage or leather knee-cap is worn and bending of the joint is gradually increased, at first given passively at the end of massage, and then permitted actively.

Fig. 388.—Fracture of the patella three months after operative coaptation by kangaroo tendon of the soft parts. Flexion and extension perfect.

Operative Methods.—Hooks of various kinds (like Malgaigne's, Levis', and Stimson's) were formerly used to coapt the fragments by inserting the prongs through the skin into the front of the bone above and below the line of breakage. *Pins* driven transversely through the ligaments or vertically into the fragments to anchor and coapt them have also been used. These foregoing methods are practically abandoned now.

Incision directly exposing the fragments for suture is the operative method of choice where and when all aseptic details are possible.

Vertical incision (Stimson's method) is very commonly used.

After the bone is exposed the fragments are held aside, and clots and loose fringes are removed and hot saline solution irrigates the joint. "A stout chromic catgut ligature is passed through the lateral expansion and capsule close to the bone on each side; these are tied while the fragments are held in exact apposition, and then the fibroperiosteum and other superficial layers are adjusted and fastened with catgut" (Stimson). No drainage is used. A posterior splint is applied, and the patient is abed with the limb elevated for a week, and then the silk skin sutures are removed and a light plaster-of-Paris cast is applied. The patient is then allowed on crutches. In a month the cast is worn only in the daytime. "Usually by the end of the

Fig. 389.—Fracture of patella, with postoperative breakage of wire suture.

third month, often earlier, the joint can be flexed at least 90 degrees, and the patient usually discards the splint entirely before that time, since he is told it serves only as a protection against damage by a fall" (Stimson) (Fig. 388).

Transverse incision methods are also used and frequently give better exposure.

Semilunar incisions, convexity upward, are also used.

Bone suture after incision is not much practised now; kangaroo or other tendon and silver or bronze wire are the materials most often employed (Fig. 389).

Before resorting to operation it is usually the practice to wait a

week or ten days for articular reaction to subside; some surgeons, however, operate immediately.

Operative measures bring about an earlier and more complete union, but suture should be done only by an experienced surgeon, preferably in the rugged and those who are able to combat surgical interference. Functionally good results are possible without it, and even under the best conditions there is some danger of sepsis with subsequent ankylosis, or perhaps amputation or death.

Early massage is a postoperative necessity and is not to be postponed beyond the time the skin wound unites. Some few surgeons allow patients out of bed after ten days and permit walking then in a cast, with bending of the knee after a few weeks.

Results.—*Fibrous union* is the rule; it may be so close, firm, and tough that in effect it is bony, but true osseous repair is rare. The fibrous bridging may be continuous between the fragments, or gaps in it may intervene, and frequently motion between the joined segments is quite marked, especially laterally. The fibrous bridge may be several inches wide and yet permit very active function; it is not uncommonly ½ inch or more wide.

Joint motion is associated with a great deal of stiffness, swelling, and pain at first, especially in the non-massaged cases. Much of this disappears within the first six months, especially if massage and increasing use are practised. When the knee can be bent to 90 degrees the functional limit of usefulness for ordinary purposes is attained; the normal extreme flexion angle is about 125 degrees. The majority of cases within a year have serviceable limbs.

Refracture is most likely within the first six or eight weeks after the cast is removed, and it is practically always due to a trip or fall. The line of fracture may be at the original site or the lower fragment may pull away the edge of the upper at a new place. Union generally re-occurs promptly and operation is practically never needed to bring this about.

E. M. Corner, of London,[1] states that the patella is more often refractured than any other bone, and that in the operated cases 69 per cent. of refractures occur in the first year after the injury. Of the unoperated cases 86 per cent. of refractures occur after the first year.

Fixation of the knee-cap by adhesions to the condyloid region is rather unusual.

Disability Period.—Total, eight to sixteen weeks; partial, four to twelve weeks.

[1] *Annals of Surgery*, November, 1910.

FRACTURE OF THE LEG

This includes (*a*) *upper end* of the tibia or fibula, or both; (*b*) fracture of the *shaft* of the tibia or fibula together or separately; (*c*) fracture *above the malleoli* (supramalleolar); (*d*) *malleolar* fracture; (*e*) *Pott's fracture.*

Anatomy and Landmarks.—*Tibia.*—It enters into the formation of the knee-, but not of the ankle-joint (Fig. 390).

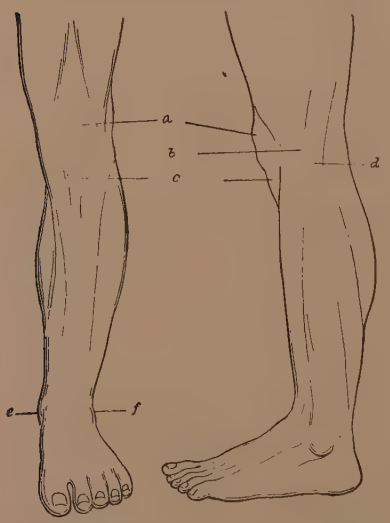


Fig. 390.—Bony landmarks about the knee-, and ankle-joints: *a*, Patella; *b*, summit of tibia; *c*, tubercle of tibia; *d*, head of fibula; *e*, external malleolus; *f*, internal malleolus.

Tuberosities, especially the inner, are often visible and always palpable; in flexion the summit of the tibia can be felt and is a good guide to the joint entrance.

Tubercle can often be seen and is always palpable; the patellar tendon is attached to it.

Shaft is largely visible and wholly palpable almost for the entire extent; the *crest* and *anterior surface* are especially well marked.

Fibula.—It enters into the formation of the ankle, but not of the knee-joint.

Head is visible usually, and always can be felt behind and below the top of the tibia; it bears a relationship like the head of the radius to the ulna.

Shaft lies well behind the axis of the tibia and is embedded in muscles at the upper part, but can be felt below the middle, and then gradually becomes visible below this level.

Lower End.—Malleoli: The *internal* is broader and thicker than the external, and its lowest *tip* lies ½ or ¾ inch above and in front of the lowest end of the fibula. The *external* is more pointed and the ridge on its back part can be made out; on its front there is often an irregularity.

UPPER END FRACTURE

This may involve either bone separately or together; in the former the tibia is usually affected (Fig. 391).

Causes.—*Direct violence* is the commonest method, usually from a blow or the impact of a falling object. *Indirect violence* is a less

likely source, as from a heavy fall with a twisting of the leg, usually outward. The line of fracture is ordinarily transverse (Figs. 392–394).

Symptoms.—These somewhat resemble a dislocation of the knee. *Disability* is instant and complete. *Deformity* is seen in *swelling* and perhaps *irregularity*. *Mobility* and *crepitus* are variable; *local pain*

Fig. 391.—Common sites of fracture of the tibia and fibula: *a*, Anterior view; *b*, posterior view.

Fig. 392.—Comminuted fracture of the upper end of the tibia and fibula (side view).

is present on direct or lateral pressure, or that transmitted through pounding on the heel.

Anesthesia is generally needed for diagnosis and *x*-ray examination may be requisite for corroboration.

Treatment.—*Reduction* is effected by pressure and traction; in some cases with comminution or irregular lines of breakage open incision may rarely be needed (Fig. 395).

Splintage.—(1) *Posterolateral molded plaster-of-Paris cast* from the toes to the upper third of thigh, the knee being slightly flexed; this is the best method when reduction is maintainable (Fig. 396). (2)

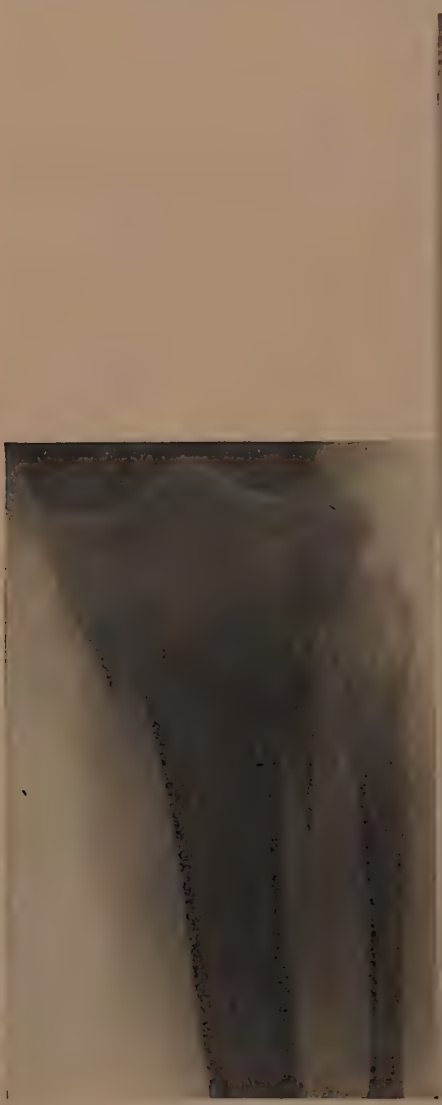


Fig. 393.—Comminuted fracture of the upper end of the tibia and fibula (fore and aft view).

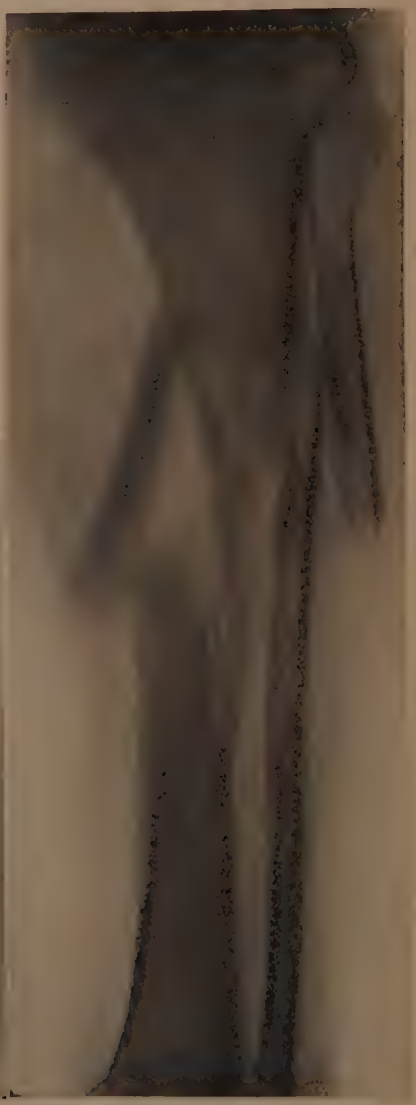


Fig. 394.—Compound comminuted fracture of tibia and fibula (upper end).

Circular plaster-of-Paris cast covering the same area; this can be bisected if desired. (3) *Posterior suspension splint*, like the Hodgen or modifications (Fig. 397). If removable splints are used, some massage

is of great assistance after the first week. Splints are removed after five to eight weeks, when union is usually firm. Then the usual treatment is given to "limber up" the stiff joint, some protective leather or

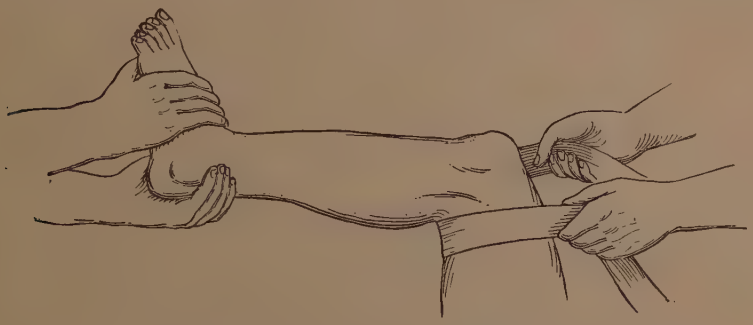


Fig. 395.—Manual traction method for fractures of the leg or ankle.

light plaster encasement being provided and worn for several weeks longer. Weight bearing is not allowed for ten to twelve weeks when the tibia is involved.

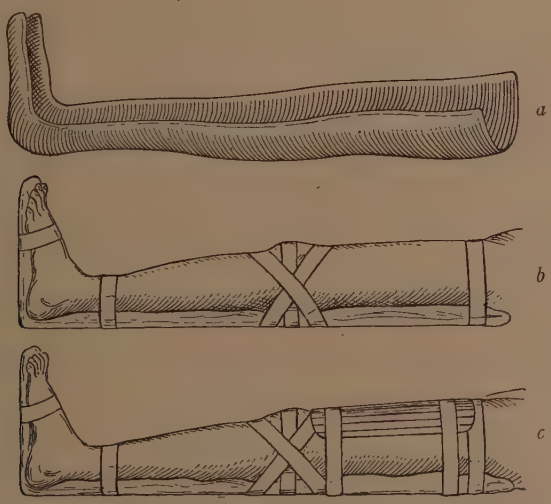


Fig. 396.—Splintage for non-displaced fractures of the leg or patella: *a*, Posterior molded plaster-of-Paris "gutter" splint; *b*, posterior padded wood or tin splint; *c*, same as preceding, with anterior reinforcement of wood or tin.

In all forms of splintage the margins of the knee must be carefully padded, especially over the head of the fibula, to prevent peroneal pressure, which causes "foot-drop" (Fig. 398).

Results.—The outcome is good in cases capable of reduction; in

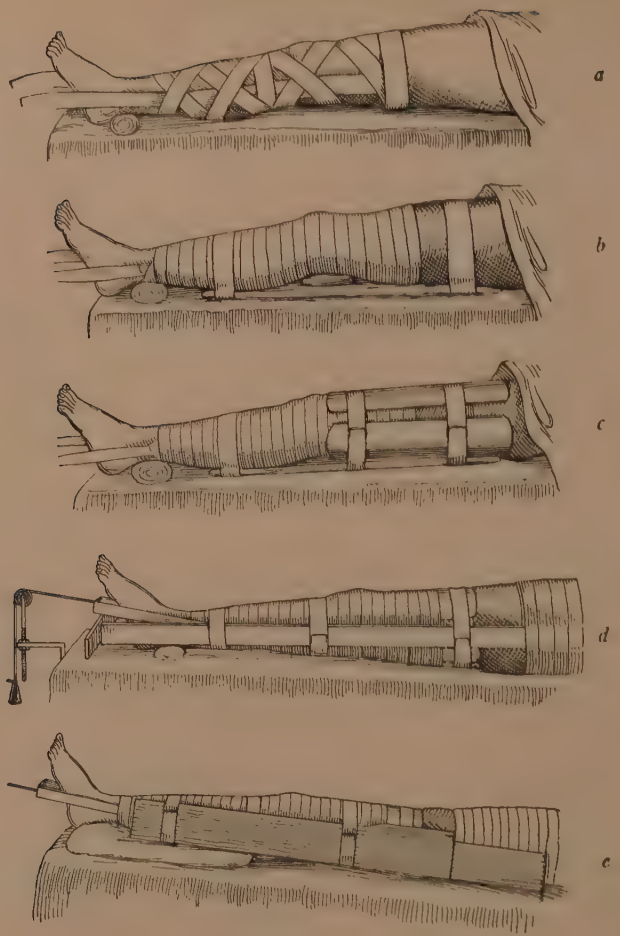


Fig. 397.—Traction splints for the lower extremity: *a*, Adhesive plaster to prevent knee-joint adhesions; *b*, posterior padded splint to the bandaged leg as in non-displaced fractures near the knee; *c*, as in *b*, reinforced by coaptation splints; *d*, *e*, lateral splints for fractured femur, as in Buck's extension.

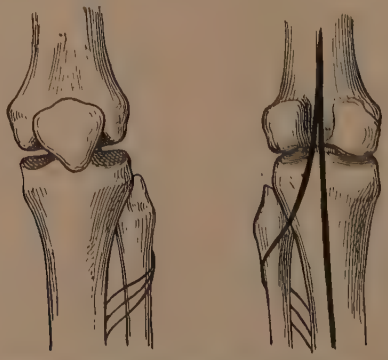


Fig. 398.—Relation of nerves passing around head of fibula. Pressure here results in "peroneal palsy," causing "foot-drop."

others some permanent stiffness of the knee is likely. The outlook is best when the fibula alone is broken.

Disability.—Total, six to twelve weeks; partial, three to nine weeks.

Epiphysis Fracture

The shaft of the tibia joins the head about the twenty-fifth year, and this form of displacement occurs usually before the sixteenth year. This is among the rarest of all epiphyseal separations and there are but few recorded cases.

Causes, Symptoms, and Treatment.—*Direct* or *indirect violence*, especially wrenching or twisting, is the commonest source of origin.

Diagnosis is made by noting swelling and perhaps irregularity and false motion; crepitus, if present, is of the soft variety; *x*-ray or incision is the determining diagnostic factor ordinarily.

Splintage is the same as for the preceding; operation may be needed.

Results are good in the reducible variety; bad in the compound and irreducible forms.

Tibial Tubercle Fracture

This is rather rare and occurs usually as a result of quadriceps contraction, by which the patellar tendon pulls away the tubercle, and in this respect it resembles the so-called sprain-fractures. Rarely it may be avulsed by a direct blow or kick.

Symptoms.—The knee is swollen and cannot be extended, and the avulsed movable bony process can be felt in an abnormal position, and when restored it will crepitate.

Treatment.—This designs to hold the knob of bone in place by adhesive straps or pads; in some cases suture or pinning is necessary. Later, posterolateral splints are used to hold the knee straight for a month or six weeks.

Results.—Even though replacement is not wholly perfect, the outcome is excellent.

Tibial Spine Fracture

This is an exceedingly rare injury and *x*-ray diagnosis alone is determinative in excluding sprains, ruptured ligaments, displaced cartilage, or dislocations, as the symptoms closely resemble all of these.

Treatment.—This is by splintage with the knee straight.

SHAFT FRACTURES

Broken legs are very common, and in my series there were 467 cases, a percentage of 8.3; 97 of these involved the tibia and 56 the fibula alone.

According to most statistics between 5 and 10 per cent. of all fractures involve the leg bones.

Causes.—*Direct violence* factors, such as kicks, blows, run-over accidents, and falls astride an object are quite common; from such causes compound (open) fracture is most likely. *Indirect violence* is a more common source, as from a fall on the foot or a wrench or

Fig. 399.—Comminuted fracture of the lower end of the tibia and fibula. End-result; note firm callus and good alignment of tibia in relation to astragalus.

Fig. 400.—Compound comminuted multiple fracture of the tibia and fibula.

rotatory twist of the leg; from this source breakage is commonest below the middle. *Muscular violence* is an exceedingly rare factor.

Varieties and Sites.—The lower half of the leg is most often involved. Simple, complete, oblique, transverse, or spiral fracture of both bones is the commonest form, the fibula breaking at a somewhat higher level than the companion bone.

Displacement varies; if the violence is not forcible and if the patient falls out of the way of it as soon as it is received, then the fracture lines will tend to stay together; if the violence continues to act after the fracture occurs, or if initially it has been great, then separation and displacement will be greater and the tibia may be forced through the

Fig. 401.—Multiple fracture of the fibula and fracture of the internal malleolus. This patient also received a fracture-dislocation of the spine in the same accident. (See Figs. 470, 471.)

skin, resulting in a compound (open) break. Compounding of the fibula is quite uncommon (Figs. 399, 400). Overlapping of fragments may amount to several inches; the lower fragments are in front generally and often almost penetrate the skin because the tibia is normally so subcutaneous. When one bone alone is broken, especially the fibula, displacement is not generally marked, as the unbroken bone

splints the other (Fig. 401). Violence great enough to break or displace the tibia is usually sufficient to break the fibula also, notably if indirect force is the causative factor. Fracture of the *lower* third of the tibia (oblique or spiral) is very often associated with fracture of the *upper* third of the fibula.

Incomplete or *greenstick* forms are rather rare and always occur before the sixteenth year (Figs. 402, 403).

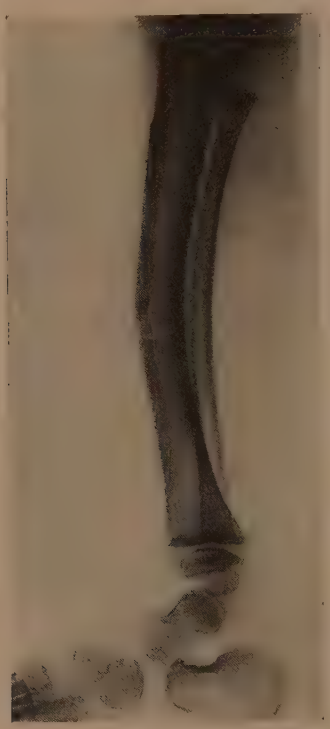


Fig. 402.

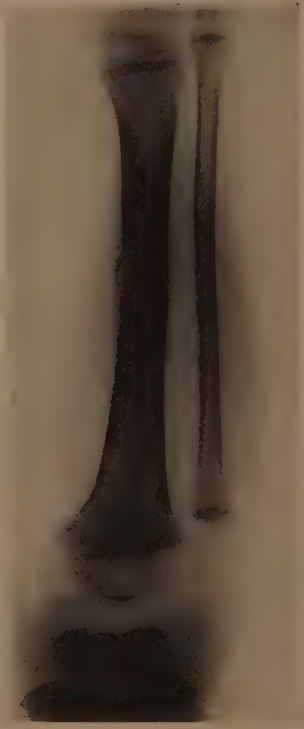


Fig. 403.

Figs. 402, 403.—Greenstick, incomplete, or bending fracture of tibia.

Compound (*open*) forms are notably common because the tibia is so close to the surface (Figs. 404–406).

Symptoms.—*Disability* is instant and complete when both bones are involved; in some few cases of unseparated tibia or fibula fracture, weight bearing has been possible for a short time. *Deformity* shows as distortion or angulation of the twisted or dangling leg; later, swelling, ecchymosis, and blebs appear. *False motion*, *local pain*, *crepitus*, and *irregularity* are present. *Measurement* from the tubercle or inner tuberosity of the tibia to the inner malleolus demonstrates the short-

ening. In cases with marked displacement the diagnosis has already been made by the patient or others, and at all events is usually apparent when first inspected by the physician. In undisplaced cases diagnosis rests upon finding *irregularity* in the crest or border of the tibia, and in

Fig. 404.—Compound comminuted multiple fracture of tibia and fibula. Original condition (anteroposterior and lateral views). This patient was in a collision between cars and for a time was in danger of amputation. Several sequestra of necrosed bone were removed.

this same region *local pain* will be elicited upon direct pressure or that produced by pounding the heel or pushing the shafts or malleoli toward each other.

Mobility and *crepitus* are demonstrated by firm grasps of the

limb, one whole hand being above and the other below the suspected site, a rocking or lateral motion best bringing it out. *Malalignment* is suggested when the anterior spine, mid-patella, tubercle of tibia, mid-intermalleolar line, and the space between great and adjacent toe are not in the same straight line. If the fibula alone is broken, diagnosis is often determined by the one sign of "point" or

Fig. 405.—Compound comminuted multiple fracture of tibia and fibula. A later stage, after partial reduction.

local pain, with perhaps the later appearance of ecchymosis. Measurement must have in mind the normal variants in length, and this may amount to ½ inch or more; confusion is most likely in bow-legged, knock-kneed, or otherwise asymmetric patients.

Treatment. *Immediate care* during transport to bed demands that the leg should be kept absolutely straight and quiet, preferably with

some pull on the foot while the limb is placed in an improvised casing made of a folded coat, skirt, or petticoat, as shown in Fig. 396. A pillow pounded lengthwise into a groove is splendid for this purpose. No pressure or constriction should be placed *just over* the fracture line. When the patient is abed the temporary pillow splint may still answer,

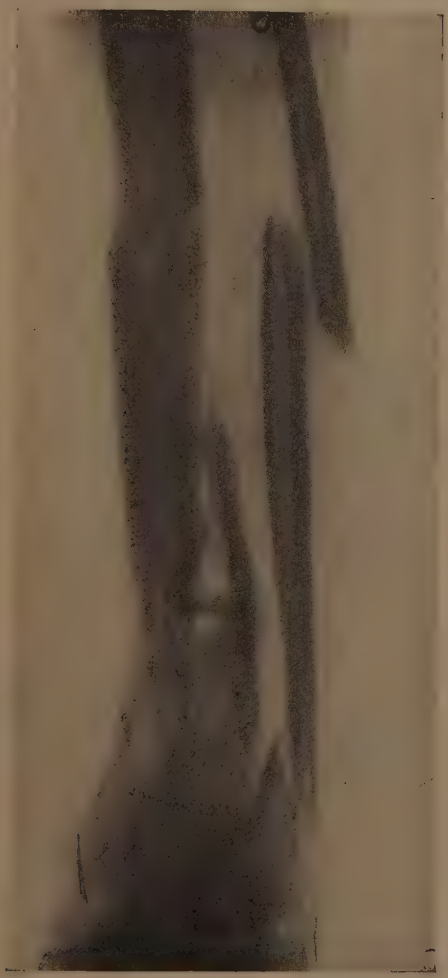


Fig. 406.—Compound comminuted multiple fracture of tibia and fibula. At the end of treatment.

and the whole limb should then be elevated as high as comfortable, as this will tend to minimize edema and circulatory engorgement.

Swelling and *blebs* may be extensive enough to make it worth while to wait a week or ten days before anything more is done; or, better, the leg may be placed in a three-sided box or metal gutter splint

(see Figs. 197, 396) and the elevation continued. Lotions (like saline, boric, or lead-and-opium solutions) sometimes aid in the absorption of effusion. Ice-bags must be used cautiously if at all.

Reduction should be made at once where practicable, and this is accomplished usually by traction on the foot, with the knee steadied. In some cases this can best be done by causing a sharp angulation of the fragments backward until they interlock, and in this position traction and extension is then made. If there is much displacement anesthesia is advisable, and the patient can be allowed to "come out" before the splint is applied.

In some cases operative reduction is necessary, and then the wound is made to the outer side of the tibial crest where the tissues are least subcutaneous. Preliminary weight traction on the foot for twenty-four hours or more is a valuable aid to easier setting.

Splintage.—(1) *Molded plaster of Paris*, posterolaterally, with the leg perfectly straight, can be used even where swelling and blebs are marked. This splint reaches from the toes to the upper third of the thigh. The whole limb should be previously shaved and washed with alcohol and then dried and powdered. Blebs are painted with iodin and opened aseptically, and if large, a layer of sterile gauze covers them; otherwise dusting with powdered bismuth or boric acid is sufficient. They often retard a smooth recovery and may cause troublesome infection or eczema if unwatched. (2) *Circular plaster-of-Paris cast* is safe only when swelling is not marked; it is applied over the same area as the foregoing, and is safer and just as efficient if split down the middle before it hardens, allowing a gap to the skin of $\frac{1}{2}$ inch or more. (3) *Suspension splints*, like the Hodgen or modifications. (4) *Wire frame splints*, like the Cabot or modifications. (5) *Traction by adhesive plaster* or weights, with some posterolateral splintage.

Whatever form is used, care must be taken to keep pressure off the head of the fibula, malleoli, and heel, and this last can be done by pads placed above the tendo Achilles or by a strap of adhesive running over the tendon and along the sole to the edge of the splint, or by the other plans shown in Fig. 407. Undue pressure over the head of the fibula may produce peroneal palsy and resultant foot-drop. Every effort is to be made to correct shortening; but a slight amount of lateral displacement will cause no serious trouble if overlapping is remedied. Splints are replaced when loose, and they are used until the bones are firmly knit, a period of five to eight weeks as a rule. Massage materially aids after the first few days; passive motion of the

ankle can be given in three weeks and of the knee a week later. After the first few days, swelling permitting, the patient can be allowed out of bed with the leg on a chair; in a week it can be allowed to rest on the floor; in two or three weeks going about on crutches is allowed. The lower leg and foot will swell and become blue and perhaps cold or painful at first, but later this disappears.

After the heavy splint is removed, a lighter and shorter support can be used a week or two. After two months, assuming that no local pain

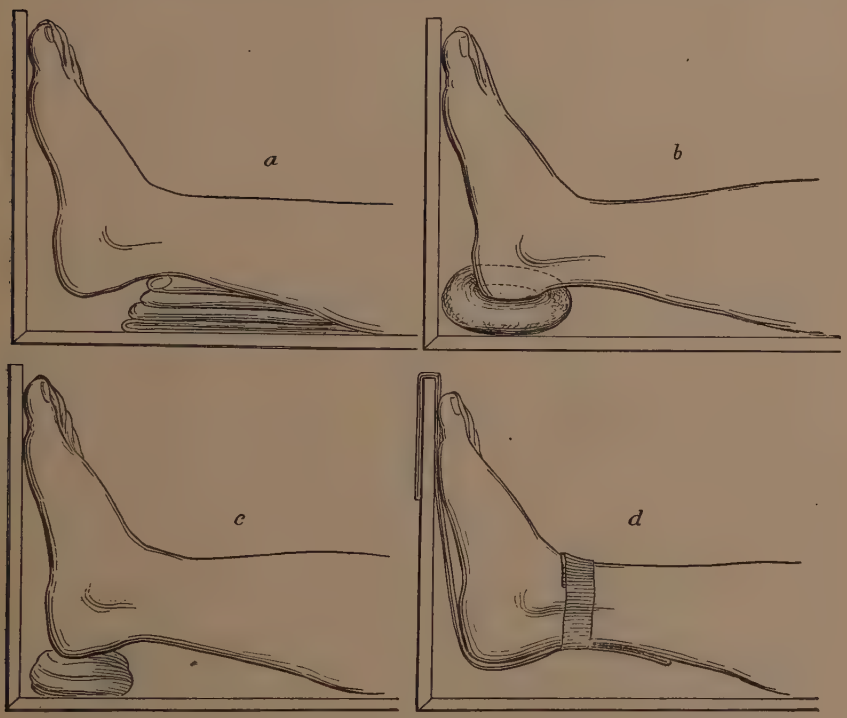


Fig. 407.—Methods of keeping pressure off the heel: *a*, Folded compresses; *b*, "doughnut" or ring of gauze and cotton; *c*, cotton padding; *d*, adhesive fastened to end of splint.

persists on increasing usage, weight is born and walking permitted, the leg being bandaged.

In compound (open) cases the use of molded or circular plaster splints, reinforced by a bent iron bar or with a window, are convenient for dressings, preliminary iodin sterilization having been accomplished.

Operation seeks to bring about coaptation by suture, pinning, or plating; neither of these act uniformly well because the main bone is so poorly covered by soft parts; hence the incision is planned as much

to the outer side as possible. The usual rule is to suture or plate the tibia only, as the fibula practically cares for itself (Figs. 408, 409).

Results.— *Union* is generally firm in four to six weeks; in compound (open) cases that stay clean it is but slightly longer; infected cases may be very much delayed or completely fail to unite and sinuses may persist for months.

Fig. 408.—Case of H. S., aged sixty-two. Compound comminuted fracture of tibia and fibula, showing end-result. An autogenous bone-graft was inserted for non-union; *x*-ray deformity apparently is great; clinically the leg is straight, very little shorter, and functionally nearly perfect.

Refracture through the original line is commonest within the first few weeks, and is usually due to a trip or fall; in such cases reunion is generally prompt and about one-half the time is required to unite the new break than was originally necessary (Scudder).

Deformity may be evident by mal-alignment, such as *bowing* (anteroposterior or lateral) or *overriding* with *shortening*. All of these may be considerable without impairing the ultimate strength or usefulness of the limb; shortening even of several inches can be sometimes compensated for without limp or gait defects.

Fracture of the fibula alone causes no shortening and is rarely of serious import.

Swelling, cyanosis, and other circulatory impairment always occur to some extent; much of this disappears after a few months of use and ultimately ceases to cause trouble or notice.

Stiffness of the knee and *ankle* is quite marked at first, especially in the latter joint. A great deal of it may be prevented by early massage and passive motion; later, active use and special efforts to limber up these joints are rewarded by increasing freedom of action and virtual return of complete function. Tendo Achilles contraction is largely prevented if the ankle is overflexed when splinted.

Fig. 409.—Bone-graft for ununited fracture of the tibia.

Callus is most marked where perfect coaptation has not occurred, and it may be visibly large, irregular, and tender; later it decreases and becomes smoother and painless.

In my experience fractures 4 to 6 inches above the ankle are most troublesome, as they are difficult to reduce or retain and often fail to unite. Frequently also they are compounded.

Disability Period.—Total, eight to sixteen weeks; partial, four to twelve weeks.

SUPRAMALLEOLAR FRACTURE

In these rather uncommon forms the line of fracture is above the base of the malleoli, and, roughly speaking, involves the shaft within a few inches of its lowest limits. The joint is usually entered by a splinter, with more or less associated comminution or separation of

fragments. The tibia and fibula may be affected together or separately (Fig. 410).

Causes.—*Indirect violence*, as a fall on the foot with or without lateral wrenching, is the usual source. *Direct violence* less often is causative, as from a run-over accident or violent blows.

Symptoms.—Associated with *disability* is *deformity* from swelling of the distorted ankle and foot, *local pain*, and perhaps *crepitus* and excessive *mobility*, especially laterally. There is a change in the appearance and level of the malleoli and irregularity may be felt.

Fig. 410.—Fracture of tibia and fibula. Note non-separation and approach to a greenstick variety.

Treatment.—This comprises *reduction* under anesthesia, and *splintage* with the foot in a right-angled inverted position, as in Pott's fracture.

EPIPHYSIS FRACTURE

Displacement of the lower end of the tibia from the shaft is nearly three times commoner than involvement at the upper end of the same bone; despite this, it is among the rarest of all ankle injuries. Union with the diaphysis occurs about the twenty-fourth year, but most separations occur before the fifteenth year.

Causes are those associated with a twist of the foot, with or without the added violence of a fall.

Symptoms.—These are like supramalleolar forms except that dis-

placement is less marked. Dislocation or "severe sprain" is usually diagnosed, and *x*-ray examination is often the final determining factor.

Treatment is like that given the following.

POTT'S FRACTURE

This exceedingly common "fracture of the ankle" occurred 393 times in my list of cases, a percentage of 8.8.

It receives its name following the description given in the Chirurgical Works of Percival Pott, 1779 edition (Cotton). Originally Pott described a fracture above the external malleolus, a rupture of the internal lateral ligament, and an outward dislocation of the foot.

Lately there has been a tendency to group *all* ankle fractures as "Pott's" or "modified Pott's," and for practical purposes this is not inadvisable (Fig. 411). The definition and classification given by

Fig. 411.—Bony landmarks about the ankle and tarsus: 1, Front view; *a*, Astragalus outer upper edge; *b*, astragalus outer side of head; *c*, fifth metatarsal head; *d*, internal malleolus tip; *e*, scaphoid tubercle. 2, Lateral view (internal): *a*, Internal malleolus; *b*, scaphoid tubercle. 3, Lateral view (external): *a*, Fifth metatarsal head; *b*, peroneal tubercle.

Stimson is regarded by me as most satisfactory clinically and pathologically, and he describes the injury as one in which the following lesions exist as a result of (1) *eversion* or (2) *abduction* of the foot (Fig. 412).

(1) *Eversion.*—The main force is exerted through the internal lateral ligament, resulting in the combination of (*a*) fracture of the internal malleolus squarely off its base; (*b*) rupture of the tibiofibula ligament; (*c*) fracture of the fibula just above the malleolus. This may rarely be modified by an avulsion or chipping of the tibia along

the line of the tibiofibula ligament attachment, the ligament remaining intact.

(2) *Abduction.*—The front of the foot makes the principal movement, resulting in the combination of (*a*) Fracture, oblique or marginal, of the anterior portion of the internal malleolus; or oftener, rupture of the anterior part of the internal lateral ligament; (*b*) rupture of the tibiofibular ligament; (*c*) fracture of the fibula 3 or 4 inches above its tip. If the force fails to continue long enough, the fibula may not break.

Causes.—*Indirect violence* is *the* cause, usually from "turning on the ankle," so that it and the foot are twisted *outward* and the weight of the body is thrown on the region of the internal lateral ligament or front of the foot. *Direct violence* is an improbable source of origin.

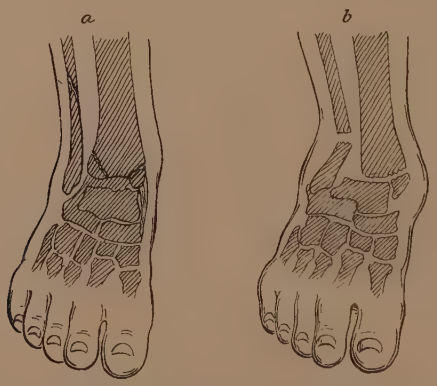


Fig. 412.—Pott's fracture showing lines of breakage with the typical abduction deformity: *a*, Fibula broken obliquely; lower inner and outer articular end of tibia broken, but unseparated; interarticular mortise slightly affected; *b*, fibula broken transversely; tip of internal malleolus broken and separated; interarticular mortise greatly affected.

Varieties and Sites.—As previously stated, these vary; but the chief element, in addition to the fibular fracture, is the separation of the tibiofibular ligament, which permits the widening at the mortise between the malleoli and the astragalus and the consequent *outward* and *backward displacement* of the entire foot. The *outward* displacement is generally slight in extent; but the *backward* distortion may amount to the entire width of the astragalus. The internal malleolus may sometimes be rotated and become so subcutaneous that compound (open) fracture results.

Cotton describes[1] a variant of ankle fracture thus: " . . . backward dislocation with the *splitting away of a wedge*, large or small, *from*

[1] *Jour. Amer. Med. Assoc.*, Jan. 23, 1915.

the back surface of the tibia at the joint—a wedge that is *displaced backward* with *backward dislocation of the foot.* . . . Fracture of the malleoli is associated with this luxation. . . ."

Fig. 413.—Pott's fracture deformity: *a*, Posterior view showing eversion of foot and prominence of the inner malleolus; *b*, anterior view showing the same and the mal-alignment of the axis of the leg to the center of the ankle mortise.

Symptoms.—*Disability* is ordinarily instant and complete, so that in typical cases weight bearing or walking is impossible. *Deformity* is prominent and pathognomonic, in that the entire foot is tilted out-

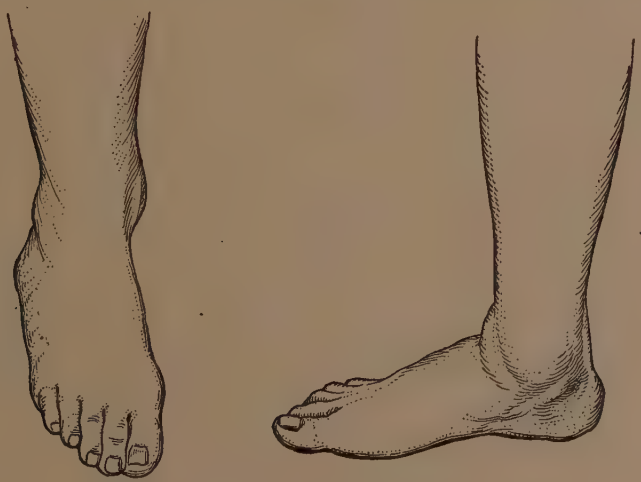


Fig. 414.—Typical deformity in Pott's fracture.

ward and backward, and in this position the inner margin of the ankle becomes unduly prominent and quite subcutaneous (Figs. 413, 414). *Lateral mobility* is another typical finding, and it is demon-

strated by placing the heel in the palm, with the other hand on the lower leg, and pushing one hand against the other. *Crepitus* may sometimes exist. *Local pain* is typically present over three areas: (1) Tibiofibular ligament region; (2) base or front border of the internal malleolus; (3) base of or a little above the external malleolus (Stimson).

Swelling and *ecchymosis* of the ankle and lower leg are prompt and extreme; blebs are less common than in fractures higher up.

Treatment.—*First aid* demands the same care as in a broken leg, so that compounding or pressure may be prevented and swelling controlled.

Reduction is the key to success, and unless it is complete, perfect function is unattainable; in this respect and in many others this

Fig. 415.—Steps in the reduction of Pott's fracture. Increasing the deformity by pushing the foot *outward* and *backward*.

injury resembles, and for all practical purposes may be regarded as, the "downstairs" form of Colles' fracture. Anesthesia is of the greatest value; if it is refused or inadvisable, some muscular relaxation will result if (1) traction is made on the ankle for some time, either by a form of extension with the leg straight, or by dangling the bent leg over a table and hanging a weight on the foot; (2) plunging the foot and lower leg into a pail of pounded ice and salt, thus attaining local freezing; (3) injecting novocain ($\frac{1}{2}$ per cent.) about the fracture site; (4) pressing upon the popliteal or femoral artery until "pins and needles" are felt in the foot.

Reduction is by *manipulation*, so made as to correct the *backward*

and *outward* deformity, and hence pressure on the heel *forward* and *inward* will accomplish this.

(1) The first step is to *increase the deformity*, and this is done by pushing the entire foot out and back. (2) The next step is direct

Fig. 416.—Steps in the reduction of Pott's fracture. Traction and elevation—the essential step.

traction downward on the foot, the leg being held by an assistant. Then the foot is lifted forward and held in a right-angled position (or

Fig. 417.—Steps in the reduction of Pott's fracture. Inversion and flexion.

beyond that angle). (3) The final step is to invert the whole foot so that the sole is almost in the same vertical line with the inner side of the leg (Figs. 415–418). The original deformity was an *outward* and

backward displacement, and it is overcorrected into an *inward* and *forward* position.

When setting has been successfully accomplished we are aware of it by (1) relief of deformity; (2) return of the malleoli to their normal levels; (3) crepitus is elicitable; (4) the leg axis is straight, so that the middle of the patella, the tibial tubercle, and the interspace of the great and fourth toes are in the same line; (5) a position of right-angled flexion can be maintained without undue force and by the push of the surgeon's index-finger—Jones' test.

Splints.—These are applied with the foot held as sharply *inverted* and *flexed* as possible. This position is maintained by an assistant who holds the toes and ball of the foot in his clenched hand; or also by

Fig. 418.—Steps in the reduction of Pott's fracture. Jones' test of reduction—if one finger's pressure maintains the correction, then reduction is adequate.

tying a bandage or string about the great toe and making the patient pull upon it.

Kinds of Splints.—(1) *Molded plaster of Paris:* This is the "Stimson splint" and it is posterolateral in type. For the posterior piece, eight to twelve layers of a 6-inch plaster-of-Paris bandage are folded lengthwise on sheet lint or wadding long enough to reach from the toes along the sole and over the heel and calf to the bend of the knee. The lateral piece begins just in front of the external malleolus, passes over the instep to the inner side and then under the sole, and up the outer side of leg as high as the other section of the splint. A bandage is then applied, snugly encircling the splint and leg, and the foot is held in position by an assistant, a sand-bag, or a tape around the toe,

and the splint allowed to harden. Then the bandage is removed and spiral straps of adhesive (or tape ties) hold the splint in place. The lateral splint may be used on the inner side in some cases. (2) *Dupuytren's* or *internal lateral* splint (Fig. 419). (3) *Circular plaster of Paris:* This is often dangerous because it hides the part and fails to give early warning of pressure; if it is used at all, it must be widely split to prevent pressure or tourniquet action.

After a week the patient may be allowed on crutches. Massage can be given from the first if a molded or similar removable splint is used. After two or three weeks, the lateral segment of a molded splint can be removed for cautious passive motion, and a week later some active bending is permissible. No weight is born for six or eight weeks. The lateral portion of the splint may then be discarded and the rest is removed in a week. Adhesive plaster straps placed about the sole to hold the foot inverted, a flat-foot insole (in each shoe), or, better, a strip of leather ½ inch thick along the inner side of shoe are useful

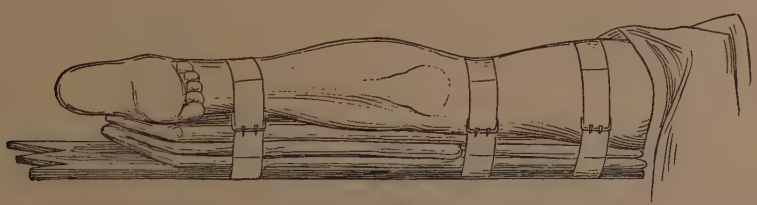


Fig. 419.—Dupuytren's splint for Pott's fracture.

when the patient first begins to walk. *Operation* for reduction is very rarely needed; in compound (open) cases it may be expedient sometimes to enlarge the original wound to bring about better alignment. Sometimes nailing or plating of the fragments may be warranted.

Results.— *Union* is firm usually in four to six weeks. *Non-union* in this or any other fracture near a joint (except the hip) is exceedingly rare. *Stiffness* and *swelling* of the ankle are always present, but are less in well-reduced and early massaged cases. A good deal of this disappears and much improvement is afforded by active use, forced bending, and other "limbering up" methods.

In badly set cases, permanent stiffness to some degree is not uncommon; in the aged, rheumatic, and alcoholic the same is also true.

Deformity in the form of a flat, everted, or twisted foot is dependent greatly upon the success of setting. Moderate degrees due to lengthening of the internal lateral ligament are generally recovered from by the aid of proper insoles, arches, or shoes; extreme or ancient forms are likely to be permanent, with more or less limp and gait awkwardness,

due to carrying the weight on the inner margin and not on the center of the joint.

"Modified Pott's" cases require no special mention inasmuch as their importance is more academic than practical.

Unreduced or *deformity cases* are often markedly benefited by an operation which exposes the fracture sites by lateral incisions; then the fragments are chiseled free and proper reduction is effected, and the wounds closed and an enveloping plaster cast applied for four to six weeks; in effect, this means refracturing the bones.

Disability Period.—Total, six to twelve weeks; partial, three to nine weeks.

MALLEOLUS FRACTURES

These are the next in frequency to Pott's fractures. The external malleolus is more commonly broken alone, but both may suffer at the same time (Fig. 420).

Fig. 420.—Fracture at base of external and internal malleolus (anteroposterior and lateral views). Treatment indicated: Posterolateral or circular plaster-of-Paris splints, foot inverted and flexed.

Causes.—The usual source is falling or tripping, producing *inversion* of the foot, so that the strain comes against the external lateral

ligament which (1) avulses the *external malleolus*, or the latter is broken by pressure of the astragalus. (2) If the violence continues, the tip of the internal malleolus is broken by astragalus pressure. (3) When carried further a larger section of the *internal malleolus* breaks (Stimson).

Symptoms.—Many of these cases are regarded as sprains or ruptured lateral ligaments. *Disability* may not be instant or complete, and walking may be possible for a time, especially in forms (1) and (2). *Deformity* shows by swelling and perhaps some visible change in the malleolus level or outline. *Crepitus*, *mobility*, and *local pain* exist.

Treatment.—This depends very largely upon the extent of the damage and the amount of displacement. In the more extensive form (3) the same care is given as in Pott's fracture. In fracture of a single malleolus, or of both with little or no ligamentous involvement or displacement, a light molded plaster-of-Paris cast for a few weeks is all that is needed. Later, adhesive strapping or an anklet may be used. Early massage is extremely useful.

Results.—These are excellent in the usual form; in complicated forms the outcome resembles Pott's fracture.

Disability Period.—Total, four to eight weeks; partial, two to six weeks.

ARTICULAR FRACTURES OF LOWER END OF TIBIA

These may involve the front or back of the bone, but are too rare to need comment, especially as they are usually *x*-ray variants of Pott's fracture.

FIBULA LOWER EPIPHYSIS FRACTURE

This is exceedingly rare alone and generally is an associate of compound (open) fracture or dislocation in children fifteen years old or less.

SUMMARY OF FRACTURES OF THE LEG

Upper end rarely involved.

Shaft.—Fracture generally affects the middle or lower third of both bones. Even with considerable mal-alignment and shortening, an eventual good functional outcome may be reasonably promised. Compound (open) fracture is probably more common here than in any other part of the body, the skull excepted.

Lower End.—Any disabling injury to the *ankle* associated with much swelling or distortion should be regarded as a fracture until proved otherwise. Pott's fracture is the common break of this region;

next commonest is fracture of the external malleolus. Dislocation should be the last and Pott's fracture (typical or atypical) the first thought in severe ankle injuries.

Reduction is the essence of treatment, and molded splints, early massage, and motion are next in importance. A stiff ankle may mean some gait defect, but not necessarily disability.

FRACTURE OF THE FOOT

Tarsus fracture is usually of the astragalus, os calcis (calcaneum), or navicular (scaphoid); the other bones are rarely broken separately (Figs. 421–423).

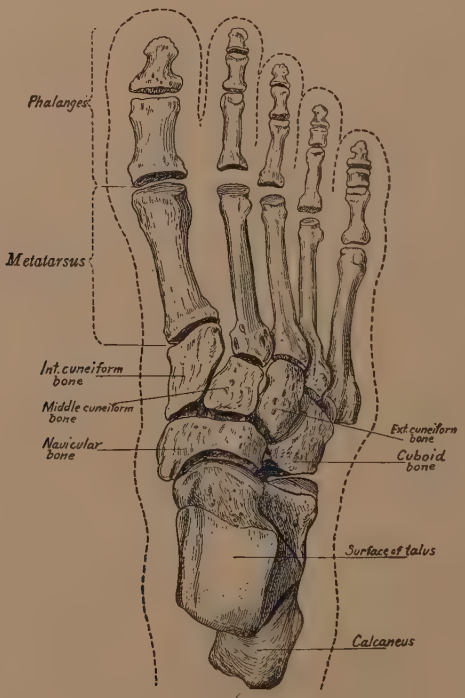


Fig. 421.—Bones of the foot.

ASTRAGALUS FRACTURE

Causes.—Usually a heavy fall on the foot, as from a height; less often a lateral crushing or twisting is responsible.

Varieties and Sites.—The *neck* or *body* of the bone are involved separately or together; the neck is oftenest broken. The line of fracture varies, and the fragments may be extensively comminuted.

Symptoms.—*Disability* is extreme and immediate and the patient cannot walk unaided. *Swelling* and *distortion* of the ankle may be

great enough to mask all other signs; occasionally *local pain*, *mobility*, and *crepitus* give clews. The *x*-ray diagnosis is determinative in nearly all cases; these plates must be interpreted carefully inasmuch

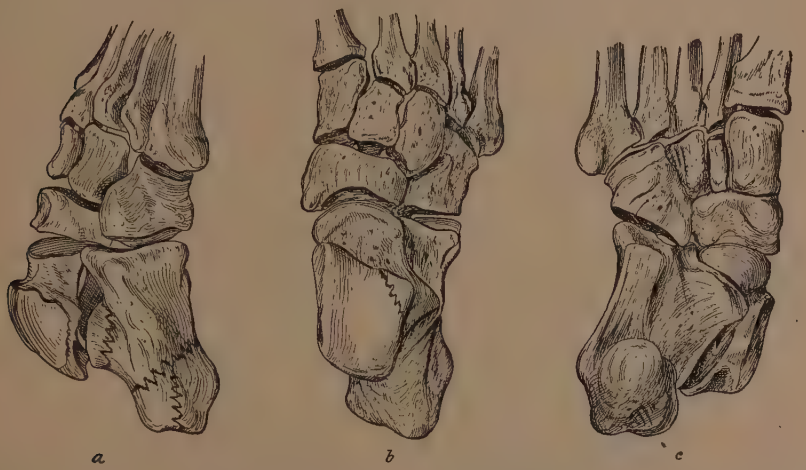


Fig. 422.—Fracture lines in bones of foot: *a*, Os calcis (calcaneum); *b*, astragalus (talus); *c*, plantar surface showing normal bones.

as there is normally in many persons the confusing so-called "os trigonum" on the posterolateral aspect of the bone, and it may exist as a detached or knobbed prominence (Keen's "Surgery").

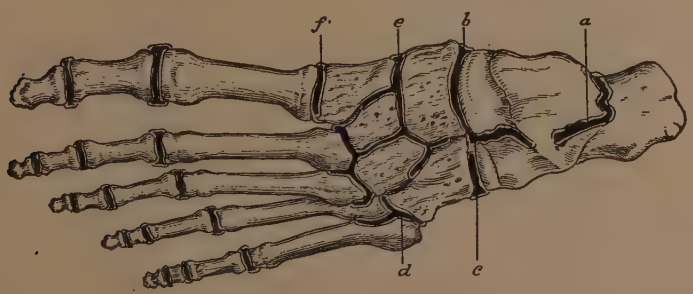


Fig. 423.—Bones of foot and their synovial pouches: *a*, Tibia—os calcis; *b*, os calcis—astragalus; *c*, os calcis—cuboid; *d*, cuboid—metatarsals; *e*, astragalus—internal cuneiform; *f*, internal cuneiform—metatarsals.

Treatment.—*Reduction* in the non- or little displaced cases is easily made by bending the ankle to a right angle; in compound (open) or badly displaced fractures excision may be needed. *Splintage* is by plaster of Paris with the well-padded foot and ankle at a right angle

and in the axis of the leg. *Operation* for removal of irreducible fragments is the best treatment for (*a*) many compound (open) cases, especially if infection is likely; (*b*) when replacement cannot be maintained, especially in neck fracture; (*c*) in comminuted cases.

Removal of part or all of the bone produces no great functional loss. Suture and pinning is occasionally done.

Results.—Union is kindly in cases with little displacement and the outcome is then likely to be good; in others a stiff ankle and flat-foot are frequent remnants.

OS CALCIS (CALCANEUM) FRACTURE

This form of injury is relatively common.

Causes.—Falls from a height on the foot or heel cause the largest number; it may also be broken by severe contraction of the tendo Achilles and by twists of the foot.

Fig. 424.—Fracture of the os calcis (comminuted).

Varieties and Sites.—Three forms of separation occur:

(1) A large posterior heel piece; (2) anterior portion, often splintered; (3) general crushing of the central or anterior two-thirds (Fig.

424) (Stimson, quoting Cabot and Binney). An *avulsion* form is due to a pulling away of a portion of the bone by the tendo Achilles (Figs. 425, 426).

Symptoms.—These simulate fracture about the ankle, and *x*-ray differentiation is usually necessary. *Swelling*, indicated by increase in the transverse diameter and *filling out of the lateral hollows of the heel*, is a main sign (Fig. 427); change in the level of the malleoli, especially the internal, is also sometimes present. Crepitus, mobility,

Fig. 425.—Avulsion fracture of the os calcis.

and local pain are variably found. Ecchymosis at the margins of the tendo Achilles is also rather typical.

Treatment.—*Reduction* is easy if little displacement occurs; otherwise operation may be necessary to accomplish it. *Splintage* is by plaster of Paris with the padded foot and ankle at right angles; usually several days of temporary splintage and the use of ice-bags or wet dressings precede this encircling cast in an effort to reduce swelling. The cast is worn six or eight weeks and is followed by adhesive straps, an anklet, or special shoe devised to prevent flat-foot.

Operation is frequently needed in irreducible cases, and this takes the form of (*a*) suture or pinning of the bone; (*b*) suture of the tendo

Fig. 426.—Avulsion fracture of the os calcis.

Fig. 427.—Relation of tendo Achilles lateral recesses to the os calcis: *a*, Normal concavities; *b*, abnormal convexities following fracture.

Achilles; (*c*) nail transfixion of the upper fragment to act as a lever. Simple tenotomy of the Achilles tendon may answer in some cases. After any of these a plaster-of-Paris dressing is applied.

Results.—These are similar to those of astragalus fracture; flat-foot and stiff ankle with impaired pronation and supination of the foot may persist to a greater or less degree in bad cases. Many of the cases show persistent widening of the heel, and it seems flattened and dropped down when viewed from behind; but, despite the deformation, the disability disappears in many cases.

NAVICULAR OR SCAPHOID FRACTURES

These are very rare, and the **diagnosis** is made by *x*-ray examination.

Treatment and **results** are similar to the foregoing.

METATARSAL FRACTURES

These are fairly common, but usually are associated with crushing injuries of adjacent parts (Figs. 428, 429).

Fig. 428.—Fracture of first and second metatarsals at different levels.

Causes.—*Direct violence* is the usual source, as from falling objects and run-over accidents; the central bones then generally suffer. *Indirect violence* is a rarer origin, as from a twisting of the foot in dancing, running, or jumping; the fifth is most likely to be thus broken.

Symptoms.—*Disability* from pain and swelling varies and the toe lines may indicate shortening. Local pain (by direct pressure or that

transmitted from the toe), false motion, irregularity, and crepitus generally are present.

x-Ray diagnosis is wise for confirmation; but the normal peculiarities must be kept in mind in interpreting the plates.

Treatment.—*Reduction* is generally unnecessary, as displacement is slight. *Splintage* is by posterior molded plaster of Paris reaching from toe-tips half-way up the calf. Some compound (open) cases need plentiful drainage, as they are prone to develop necrosis.

Fig. 429.—Left foot. Fracture of phalangeal ends of second, third, fourth, and fifth metatarsal bones. Fragments fairly in good position.

Results.—*Union* is complete in three weeks. Some callus may remain prominent and painful at first, but later it decreases and becomes painless. Flat-foot may occur if two or more bones are broken and if replacement is ineffective.

TOE FRACTURES

These are uncommon by comparison with the fingers.

Causes.—Usually *direct violence* is causative, as in crushing, vehicle and machinery accidents, hence they often are compound (open); less commonly they occur from "stubbing a toe."

Symptoms.—*Disability* varies. Swelling, local pain, mobility, irregularity, and crepitus are the usual signs.

Treatment.—Traction or manipulative reduction is made if necessary. *Splintage* may be formed of a mold of plaster or a thin padded board along the sole to bind the whole foot for a couple of weeks; or two adjacent toes can be made to splint the broken toe by encircling all three with adhesive. Traction or extension may sometimes become necessary.

Results.—Generally the outcome is good; "hammer-toe" or allied deformity may result if setting is imperfect.

CHAPTER VIII

DISEASES OF THE BONES

PERIOSTITIS

By this is meant inflammation of the periosteum or fibrous covering of the bone.

It is exceedingly rare as an isolated *acute* traumatic process because present-day methods of diagnosis usually demonstrate more or less inflammation of the bone as an accompaniment; hence cases formerly regarded as involving periosteum alone are now usually regarded as examples of osteoperiostitis.

However, in the form of *chronic* periostitis, a localized thickening of periosteum often occurs, notably in connection with long-continued or repeated irritation of bone not well covered by soft parts. This manifestation is quite common along the shaft of the tibia in connection with contusions and hematomata of the shin; it is especially frequent in leg ulcers and infected wounds thereof. Likewise it occurs in certain infections, notably syphilis, tuberculosis, and less often in typhoid fever.

In connection with long-continued suppuration there may develop over several of the bones a peculiar general periosteal thickening known as *toxic osteoperiostitis ossificans*, not unlike the rather general periosteal thickening often seen in syphilis.

Traumatic periostitis, as the outcome of falls, blows, joint violence, wounds, and other forms of irritation, occurs only when the bone is relatively superficial or subcutaneous, and the most typical forms are seen on the shin, as stated. Such a manifestation is known to the laity as a "stone bruise," and the barefooted occasionally develop thickening over the os calcis from continued pressure, and the same may occur on the shin from direct blows or infected wounds.

Periostitis in protected bones is, then, exceedingly rare in the absence of involvement of the cortical or other bone layers.

Symptoms.—Nodulation, swelling, or thickening, usually localized, is the main feature, and this is associated with pain which becomes more marked on motion or pressure. Local heat and redness occasionally occur; and in infective cases there is fever and sometimes chills,

together with adhesions of the soft parts to the underlying bone or its covering. In most instances of traumatic origin the periostitis is but a part of the associated injury to the soft parts (as contusion, wound, hematoma) or bone (as fracture or osteitis).

The *x*-ray examination in cases of periostitis discloses a wavy line of thickening that blends more or less abruptly into the adjacent bone.

Treatment.—Rest, elevation, and the application of some mild lotion usually suffices in the acute cases; in those of longer duration incision and perhaps cureting may be needed, and in such instances a thin shell of bone may also be involved and require removal. It is unwise to interfere for swelling or thickening alone, for such an irregularity is benign, and the vast majority subside unless made worse by meddling that often leads to bone infection.

OSTEOMYELITIS

This means an inflammation of the bone due to some infective agent, most cases developing from pyogenic organisms (staphylococci or streptococci); other cases may arise from infection by the germs of tuberculosis, typhoid, gonorrhea, pneumonia, and other agencies.

The process always begins in the bone-marrow and may spread throughout this before penetrating the tougher cortical layer of the bone. Often the process is metastatic in origin, as the infective organisms are carried by the circulating blood often from a far distant focus and not infrequently at a period quite distant from the receipt of the original lesion.

It not uncommonly occurs as a more or less remote complication of an illness so trivial that few if any symptoms were originally present. Tonsillitis and other forms of oral sepsis, la grippe, boils, furuncles, infected wounds, and other germ-caused affections are all potentially capable of producing osteomyelitis.

About one-half the cases occur between thirteen and seventeen, that is, at the age of bone development (Nichols, in Keen's "Surgery"). Long bones, like the femur and tibia, are usually involved; but it may appear in any bone.

Tuberculosis of bone almost always begins at the joint end or epiphysis; however, osteomyelitis almost always begins in the shaft or diaphysis, and this topographic relationship is very often a valuable factor in differential diagnosis. Usually one bone at a time is involved, but it may affect several bones coincidently.

Traumatic sources of direct origin are limited practically to infected compound fractures and wounds that harbor infective materials. Less

often an infected amputation stump or an ulcer over a subcutaneous bone may prove a source of origin. Many of the cases due to injury begin as a periostitis and by contiguity affect the subjacent bone.

It is sometimes asserted that a direct injury to a bone so lowers the local resistance that circulating germs migrate thither and set up osteomyelitis. This does occur, but it must be rather rare because of the very great number of direct injuries to bone and the relatively small number of subsequent cases of osteomyelitis. For this reason such a source of origin would only prove adequate in the absence of any other more probable or usual causative factor. In such an instance the microscopic examination of the exudate might prove of value in determining the nature of the infective agency. In this connection, however, it is to be remembered that an osteomyelitic sinus generally shows a mixed infection, staphylococci predominating.

Oral sepsis (tonsils, teeth, and gums) must not be overlooked as a potential etiologic factor, and, indeed, a pus focus in any part of the body may be the initiating element entirely independent of any supposed source of origin the exact relationship of which is recalled only by questioning the patient.

Pathology.—As indicated, the process almost invariably starts in the marrow and nearly always invades the diaphysis (metaphysis) first, but may spread therefrom to or through the epiphysis and thus involve the joint. In development the condition is not unlike a furuncle, and, indeed, it has been called "bone furunculosis," inasmuch as from a given focus in the marrow an area of necrosis occurs, and this subsequently is infiltrated by leukocytes leading to a pus collection or "bone abscess." Extension then proceeds through the various marrow-cells until more or less of the central part of the bone is involved. The cortex soon becomes invaded, and thus the exudate reaches to the surface and appears under the periosteum in the form of a "subperiosteal abscess." This may remain localized or strip the periosteum over a large surface. The next step is invasion of the soft parts and the development of an abscess in them, and this may subsequently perforate the skin.

Occasionally a definite separation of diaphysis from epiphysis may occur because of the exudate, and this is known as one form of "spontaneous fracture."

Repair is brought about by the development of new bone from the outer layer (periosteum) and inner layer (endosteum) of the cortex. The new shell of bone formed by the periosteum is known as the *involucrum*, and it surrounds the remnants of the necrotic shaft known

as the *sequestrum*, and in time tends to wholly replace it. The endosteal new bone walls off the sequestrum by an osseous plug, and this may become dense if the process long continues.

Sometimes, notably near the epiphysis, a definite sequestrum does not form, but instead an abscess occurs within a wall of eburnated bone, and such a purulent collection is then known as a "Brodie abscess."

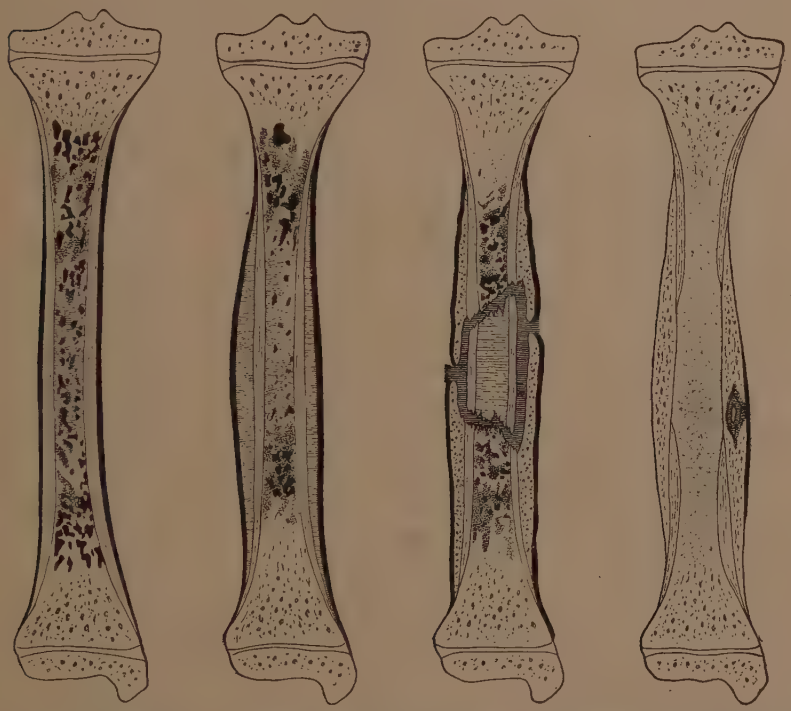


Fig. 430.—Diagram of changes occurring in a case of acute osteomyelitis of the tibia. In the first figure there is diffuse suppuration in the medulla of the diaphysis. In the second figure the products of inflammation are seen, filling the space between the cortex and the periosteum. In the third figure new subperiosteal bone has been formed, and within this involucrum is seen a large sequestrum, surrounded by pus, which discharges through openings in the involucrum, known as cloacæ. In the fourth figure only a small cortical sequestrum remains, the involucrum has become very dense, and the medullary cavity is replaced by eburnated bone (de Quervain).

A somewhat similar area of softening sometimes occurs with gummata, but the surrounding bony wall is then soft and not ivory-like.

Symptoms.—The various manifestations are often said to consist of four stages: (*a*) Acute stage of necrosis, suppuration, and sepsis; (*b*) subacute stage of purulent discharge; (*c*) chronic stage of sequestrum, involucrum, and sinuses; (*d*) stage of localized bone abscess.

In all stages the symptoms are (*a*) local and (*b*) systemic.

(*a*) *Local Symptoms.*—The onset is sudden with very acute pain as the main element; fever and chills may be accompaniments. Pain generally appears in the shaft or near the epiphysis, and it is accentuated by pressure or percussion. Swelling, heat, and redness occur very promptly over or near the site of the pain, and in many cases the signs then resemble an abscess of the soft parts. The adjacent joint may also become swollen, tender, hot or red, and, indeed, the appearance is such that an arthritis (rheumatic or otherwise) is often simulated. If an abscess appears subcutaneously and ruptures, the sinus may be single or multiple, and the margins of it are pouting and irregular, and an introduced probe discovers rough, uncovered bone.

(*b*) *Systemic Symptoms.*—Fever, pulse rise, and signs of sepsis are quite to be expected, and, indeed, these patients are often very ill. In some instances the constitutional signs are so overwhelming that the local evidences are lost sight of, and the picture then is not unlike a fulminant typhoid, especially as delirium is quite common. Blood examination gives a high leukocyte count as a rule.

Subacute, *chronic*, *subsiding*, or *recurrent* cases present symptoms similar to the foregoing, but far less urgent or severe. In these, pain, swelling, and sinuses are usually present, and from the latter more or less foul purulent discharge exudes. Occasionally abscesses occur in the shaft without any communicating sinus (Brodie's abscess). These abscesses may remain dormant for long periods and give no symptoms aside from slight enlargement of the bone and perhaps tenderness on pressure or percussion. From various causes (ascribed or ascribable) such abscesses may become temporarily active with many evidences of acute osteomyelitis, and then subside for varying intervals; in many such the pus collection may be exceedingly small and even escape *x*-ray localization, especially as no definite sequestrum may ever form, but in other cases large collections of walled-in pus are found.

Treatment.—*Acute* cases are regarded as abscesses and treated accordingly, namely, by incision and drainage over the place of maximum swelling, fluctuation, and pain. The cortex is chiseled or trephined so that the exudate in the marrow may freely escape. The interior of the bone is manipulated only enough to allow a free vent, and all cureting or scraping is contra-indicated.

In early or favorable cases no sequestrum may form and the opening closes by granulation; but in the majority of instances separation of the sequestrum is the next indication for treatment. The

rule as to this was to wait until the sequestrum was movable before removing it, but this has numerous exceptions. According to Nichols (Keen's *Surgery*), the treatment of such a condition is in four stages:

(1) *Removal of Sequestrum while the Periosteum is Plastic.*—This is mainly applicable in the leg or forearm where one bone only is involved and where there has been extensive destruction of the diaphysis. The time for the operation is when the periosteum shows well-marked ossification in the deeper layers, usually about the eighth week. At this time the layer of bone formation on the periosteum should be about $\frac{1}{16}$ inch thick. The periosteum at operation is stripped from the necrosed parts beneath, and then the sequestrum is removed and the ribbon-like periosteum fastened together to later develop a new shaft. The first evidence of new bone formation is generally visible at the end of three weeks, and the shaft is strong enough for use in from five to eight months.

(2) *Removal of Sequestrum when no Accessory Splint Bone is Present.*—This operation can be undertaken when the total diameter of the involucrum equals one-half the diameter of the normal shaft, and this occurs approximately three months after the acute infection. This procedure should be reserved for selected cases only.

(3) *Chronic Stage with Dense Involucrum and Extensive Sequestrum.*—Here we find an old necrotic shaft perforated by many sinuses and often freely movable within a shell of dense periosteal bone. Removal of the sequestrum may be indicated, but as a matter of fact the cavity left after such removal is very difficult to close. Attempts may be made to induce closure by blood-clot organization or by the method of Mosetig-Moorhof or Neuber.

(4) *Chronic Localized Abscess of Bone.*—These are chiseled or trephined and the remaining cavity is allowed to fill in by blood-clot, Mosetig-Moorhof's wax, or Neuber's skin-flap method.

Many of these bone cavities are also obliterated by the use of bismuth paste, as advocated by Beck, and a certain proportion of these cases are markedly benefited by serotherapy.

At the onset of pain and other local signs in or near a joint it is especially necessary to apply extension, so that the articulation may not become fixed by adhesions or joint exudate.

General treatment requires the use of the same remedies applicable to other forms of sepsis, and of these, forced feeding and abundance of fresh air and sunlight are exceedingly important.

Myositis Ossificans

This is a rare condition in which osseous material is deposited in muscles, often in a form that simulates a neoplasm. Pathologically, it is a chronic productive osteitis. It may be traumatic or arise from unknown sources.

Occurrence.—Traumatic cases are due to direct violence, such as severe blows or falls, and the lesion most commonly is found in the front of the thigh, next oftenest in the adductors of the thigh, and next in the flexors of the arms.

According to Coley,[1] there are three more or less well-defined forms, viz.:

(1) **Myositis ossificans progressiva,** which invades many muscles until nearly all are involved; it commonly begins in the trapezius or latissimus dorsi.

(2) **Localized forms** due to repeated or chronic irritation, resulting in osseous formations like the dancer's heel, the rider's leg, and the soldier's chest, due respectively to persistent dancing, riding, and pressure of a weapon.

(3) **Myositis ossificans traumatica,** due to a *single* trauma, such as a heavy blow, a kick of a horse, or an injury received in some such sport a as football.

Most of the cases are reported by Binnie,[2] Robert Jones,[3] Cahier,[4] and Lapointe.[5]

Many of the cases were first diagnosticated as osteomata or sarcomata, and in some instances amputation was advised. DaCosta reports one case that subsequently developed into sarcoma and Coley adds another of the same sort, so the question arises as to whether or not these enlargements are not allied more or less intimately with the sarcoma group.

Their origin is not definitely known, and of the four theories advanced most weight is given to that in which the enlargement is supposed to proceed from a piece of periosteum detached by the original injury and implanted in the muscle. Others believe the origin to simulate that of a true neoplasm. Jones (quoted by Coley) states that nine-tenths of the cases show marked tumor formation within the first two months, the majority appearing within a month.

[1] *Annals of Surgery*, March, 1913.
[2] *Ibid.*, September, 1903.
[3] *Arch. Roent. Rays*, 1905, 1906.
[4] *Rev. de Chir.*, 1904.
[5] *Ibid.*, November, 1912.

Symptoms.—Soon after the injury, a hard, painful, and rather regular swelling is found embedded in muscle, and it may or may not be firmly attached to the bone beneath. The nearer it is to the joint, the greater the loss of function, and the stronger the probability of vascular involvement leading to edema. The size and contour are variable. *x*-Ray examination should be made in all cases.

Differentiation has to be made from contusion, hematoma, myositis, periostitis, osteoma, peri-arthritis, or syphilitic tumors, and *x*-ray examination is the best means short of exsection of a portion of the mass for microscopic examination. The radiograph of a sarcoma, according to Coley, fails to show the sharp outline at the tumor-bone junction characteristic of myositis ossificans, although early sarcoma formation may closely simulate. Sarcoma is less painful and less uniformly hard than the tumor of myositis ossificans, and the latter is more likely to cause early disturbance of function.

Treatment.—Conservative treatment is advisable, as many cases spontaneously retrogress if given absolute rest. Makin,[1] quoted by Coley, was able to show 2 cases practically well after six years, and in these resorption was almost complete without interference.

Early removal is inadvisable and may be harmful and lead to recurrence, for as stated by Godlee[2] and quoted by Coley, " . . . the operation is inflicting another traumatism upon a part, which for some reason has shown a special tendency to the development of bone, and it cannot therefore be surprising if renewed activity of the process should follow."

The propriety of excising a section for microscopic examination is debatable and should be limited solely to cases resembling sarcoma.

Exsection may become necessary if function is impaired, and then the mass should be removed as carefully and as late as possible.

[1] *Trans. Royal Soc. of Med.*, 1911, p. 133.
[2] *Trans. Royal Soc. of Med., Surg. Sect.*, 1911.

CHAPTER IX

DEFORMITIES OF THE HANDS AND FEET

Some of these are due to injury, but the majority are congenital or the outcome of various systemic infections or other non-traumatic agencies.

Ganglion; Weeping Sinew

This is a cystic swelling occurring along the tendon sheath, especially on the dorsum of the wrist. According to the latest views they are regarded as colloidal degenerations of localized areas of connective tissue adjacent to a joint or tendon. Paget says they are due to cystic degeneration of the synovial fringe inside a tendon-sheath, and that the fluid of the ganglion and that of the sheath do not intercommunicate. Others maintain that a simple ganglion is a hernia of synovial membrane through a rent in a tendon-sheath, and that the canal between soon becomes obliterated.

Varieties and Causes.—*Simple* ganglion is unilocular and solitary and may be due to long-continued strain, pressure, or other factors capable of inducing inflammation of the tendon-sheath (thecitis). In some instances it may arise from any of the producing causes of synovitis, of which rheumatism is a type.

Compound ganglion is multilocular and more than one swelling exists. They are nearly always tubercular in origin, constituting tubercular thecitis.

It is certainly unusual to have the condition occur from sudden or acute trauma, and they are rarely if ever seen in association with such injuries as sprains, dislocations, and fractures. Most of the cases arise from unknown or forgotten causes, but the patient is usually able to revert to some muscle-strain which may actually be more or less directly connected with the enlargement.

Symptoms.—A painless rounded swelling is usually visible on the back or front of the wrist, and this may vary in size from a pea to a small egg, and certain motions may cause it to partially or wholly disappear. Occasionally they may also be found as small swellings on the fingers and at the metacarpophalangeal junction. The lump is not adherent to the skin, but is found to be attached to the parts beneath, and when extruded it can be moved laterally. In the

early stages the enlargement is apt to be harder than when the cystic process has caused softening and a greater degree of fluctuation. Variations in volume may occur, and some spontaneously disappear. The contents are viscid or gelatinous and of yellowish color.

Treatment.—*Subcutaneous rupture* is the old-fashioned form of treatment, and this is administered by making the lump prominent and tense and then smashing it by some heavy object, such as the edge of a book. *Injection* of iodin, carbolic, or iodoform is also advised. *Incision* and evacuation of the contents is another form of treatment. *Excision* of the sac and its contents under local or general anesthesia is the best form of treatment.

Whatever method is chosen, one essential is to later firmly compress the part and enjoin complete rest for several days. Recurrence is not unlikely if exsection has been incomplete.

Small ganglia and others that are not cosmetically annoying are let alone, and it is to be remembered that many spontaneously subside.

Trigger-finger; or Snap-, Lock-, or Jerk-finger

This is an odd condition in one joint so that when the patient tries to flex or extend the digit the act is normal up to a certain limit, and then the joint locks and is made to act beyond this by a sudden strong muscular effort which causes the finger to snap or jerk, and often this is audible and is always visible, although it may be done very quickly by an adept. It occurs most commonly in the middle, ring, thumb, and index digits.

Causes.—It may be congenital or acquired. Rheumatism, gout, arthritis deformans, and other inflammatory non-traumatic causes are frequent sources of origin. Elongation of a tendon-sheath from nodulation, loose cartilage, a sesamoid bone, or ganglion may also be at fault. Isolated injury is a rarer cause than prolonged or repeated trauma, and thus occupation may be the producing element. Occasionally it may be learned as a trick.

Abbe (*Medical Record*, March 7, 1914) says that the exact location of the difficulty is under the extreme flexor crease of the palm and is caused by a crumpling up of the tendon at this point, just as a tape might crinkle and refuse to pass through a slot. He reports a cure by an incision $\frac{1}{2}$ inch long over the tendon at this flexor crease.

Treatment.—Operative removal of some mechanical cause is the necessity, and in many instances this is followed by tenorrhaphy. Acute cases are treated by rest, lotions, splintage, and later by massage and gradual motion.

Mallet-finger; Drop-finger

This is a bending downward or flexion of the last joint of a finger due to rupture or loosening of the extensor tendon at the dorsum of the joint affected.

Causes and Symptoms.—Any injury severe enough to forcibly bend the last joint of the finger is a competent cause, as in effect the condition is one of ruptured or stretched tendon. Open and closed wounds, some fractures, and occasionally rather trivial violence are the usual etiologic elements.

Treatment.—The torn tendon is sutured to the periosteum of the distal phalanx and a padded splint is applied for three weeks, and then motion is allowed increasingly.

Baseball Finger

One form is the reverse of the preceding, and is due to a forcible bending backward of the distal joint, the tip or end of which is struck by a baseball. A dislocation, fracture, or arthritis may be an accompaniment. This condition is treated by tenorrhaphy if no bony injury is at fault. Another form of baseball finger resembles a gouty arthritis with a thickened distal joint bent forward or laterally, or both, and this variety is often the outcome of a dislocation, fracture, or arthritis.

Flat-foot; Pes Planus; Splay-foot; Pronated Foot

This refers to a common deformity of the foot in which the antero-posterior arches are weakened so that an abnormally large portion of the sole touches the ground. It is frequently associated with considerable abduction, eversion, or pronation of the foot, so that a line drawn down the center of the leg and continued over the dorsum of the foot strikes well inside the web junction of the great and adjacent toe. The process is not, in reality, an anatomic disarrangement or malposition of the bones of the foot, but rather a stretching, sagging, or shortening of the soft parts binding the bones together, so that the articular surfaces of the tarsal bones, especially the astragalus, face the wrong way.

Varieties and Causes.—Congenital and acquired forms are described, and it may be unilateral, but frequently is bilateral, and is somewhat more common in adult women than men.

Of the acquired type, the commonest is the so-called *static* form, due to an incapacity of the foot to properly balance or support the superimposed body weight. This may be due to inadequate muscu-

lature from a wide variety of causes, such as general bodily weakness, obesity, prolonged standing or walking, occupational flat-foot, improper shoes (especially the narrow-toed, high-heeled sort), shortening or contraction of the calf muscles or tendo Achilles.

The *paralytic* form comprises the group due to poliomyelitis, rickets, arthritis, spasticities, and other inflammatory conditions.

Traumatic factors are Pott's fractures, fractures of the leg, dislocations of the ankle, and some severe lacerations of the ligaments of the ankle. Less often, fractures of the tarsus may be responsible.

The cases due to injury are quite uniformly associated with bony deformity of the ankle or the parts above, and most of them are due to imperfect or improper reduction and immobilization.

Symptoms.—These depend upon the degree of deformity and the weight and general physique of the patient.

Early cases complain of weakness, pain, and fatigue on standing and walking, and this may be most marked in the foot or radiate to the ankle or leg. Many of these patients are treated for and regarded as having "rheumatism" or "neuritis." The gait may be altered and the patient may shuffle along or develop a method of walking that is found to relieve strain, and thus toeing-in is acquired in many instances.

Fig. 431.—*a*, Imprint of a normal sole; *b*, imprint of a flat-foot sole.

Advanced cases show exaggerations of the preceding, and the pain becomes more marked and continuous and may radiate along the sciatic distribution and into the back, and simulate sciatica or a spinal neuritis. Such patients usually have more or less abduction or eversion, and the soles indicate that the inner side of the foot bears most of the weight, and the gait is correspondingly affected.

Some of these patients have radiating pains inasmuch as muscular equilibrium is badly maintained, and they may show static ataxia, and because of this and the other signs are sometimes suspected of having "spinal" or other forms of "neurasthenia."

Either grade of severity may be *rigid* or *flexible* and some marked cases give no symptoms whatever; others of minor grades may be quite painful or actually disabling.

The exact extent of flattening can often be determined by making

an impress of the sole and comparing the relation of that outline to the normal. For this purpose the sole may be moistened with ink, oil or water, or dusted with talcum, and then the weight of the entire body is borne on the feet and the impress thus obtained (Fig. 431).

Treatment.—*Paralytic* forms require special shoes, braces, operations, or other orthopedic agencies.

Static and *traumatic* forms are much benefited by systematic heel-and-toe exercises, proper shoes, and the wearing of a flat-foot insole or "arch supporter." Rigidity is converted into flexibility by operative or non-operative means when indicated. Very severe and otherwise intractable cases require osteotomy, and in some cases the tendo Achilles has to be cut.

HAMMER-TOE

This is a flexion deformity of the first interphalangeal joint (usually of the fourth toe), so that the tip touches the ground and the distal end of the first phalanx forms a dorsal prominence.

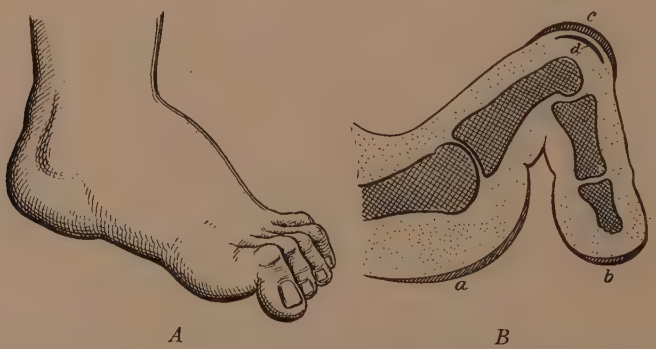


Fig. 432.—*A*, Hammer-toes; *B*, *a*, *b*, *c*, callosity of soft parts; *d*, bursitis and prominence of proximal phalanx.

It is usually congenital and only results from trauma if the toe extensor tendon is involved at the site of the lesion, as by a wound or other severing cause. Corns and bunions and actual ulcerations may occur from pressure (Fig. 432).

Treatment.—Early cases may be cured by a plantar splint. Excision of the flexor tendon and lateral ligaments, followed by splintage, is the usual necessity. Exsection of the joint or perhaps amputation may be needed in very rebellious cases.

METATARSALGIA; MORTON'S DISEASE

This is also known as anterior metatarsalgia and "Morton's toe," and it is a painful affection referred to the base of the third and fourth

toes due to pinching of a plantar nerve between the heads of the metatarsals in this area. It is usually due to tight or improper shoes and it is often an associate of flat-foot or other pedal imperfections.

Symptoms are neuralgic and quite severe, and pain sometimes may be spontaneously produced by lateral pressure of the metatarsals against each other, and often is induced by prolonged walking or standing.

Treatment is best afforded by proper shoes and the correction of flat-foot or other accompaniments. Immediate relief comes from rubbing, or spreading the toes apart during the attack. Very rarely operation may be necessary to excise the head of a metatarsal or a portion of the nerve.

Painful Heel; Policeman's Heel

This is a condition of tenderness on the under side of the heel due to osseous spur formation on the os calcis, very commonly gonorrheal in origin. It may also be due to a bursitis of the bursa under the os calcis, or it may be an associate of flat-foot or prolonged standing.

x-Ray diagnosis is usually determinative.

Treatment is by an insole plate so arched that pressure is relieved; or an operation removes the offending spur.

Achillodynia; Postcalcaneal Bursitis

This is an inflammatory condition of the bursa at the insertion of the tendo Achilles into the os calcis.

Pressure from shoes or overuse of the calf muscles are the usual causes; it may be rheumatic or gonorrheal in origin as well.

Treatment is rest and lotions; very obstinate or recurrent cases may require incision, injections, or exsection.

Coxa Vara

This is also known as *infraction* or *incurvation of the neck of the femur*, and is typified by a downward bending of the femoral neck so that the angle between it and the shaft approaches a right angle rather than the normal variant of 120 to 140 degrees.

Causes.—These may be rickets and tuberculosis, arthritis deformans, and other destructive bone diseases that are often bilateral.

Traumatic forms are usually the outgrowth of epiphyseal separations in the young and impacted fractures of the femoral neck in the aged, both being usually unrecognized at the time of the original injury. Another group occasionally occurs from too early weight bearing following injury about the hip-joint.

Symptoms.—Limp, eversion deformity, and impaired active and passive motion are the usual signs. The trochanter is above Nélaton's line and this is a differential point of importance.

In many of these cases the initial injury is not wholly disabling or significant, and attention may not be drawn to the real condition until limp, deformity, and disability suggest *x*-ray examination, which determines the diagnosis. The acetabulum is found free and the head of the bone is in place. In children the condition closely simulates tubercular hip-joint disease, and less often congenital dislocation.

Treatment is not very effective, but in children forced bending may be useful, and then the limb is put up in a position of marked abduction after the method of Whitman, as described in Fracture of the Neck of the Femur. In the aged, treatment is like that given for fractured neck of the femur.

Coxa Valga

This is the reverse of the preceding, and it is a very rare congenital condition or is due to destructive bone changes.

Dupuytren's Contraction

This rather rare deformity of the hand and fingers is an obscure affection of the palmar fascia characterized by slow onset, with periods of accession and remission, but withal progressing and leading to contractures of the fingers.

The following is taken from the author's article, "Injury and Dupuytren's Contraction," read before the Clinical Society of the New York Post-Graduate Medical School and Hospital, June 18, 1909.[1]

The name arises because of Dupuytren's classical description growing out of his studies and operations at the Hôtel Dieu in Paris. I have had the good fortune to receive a copy of Doane's English translation of the "Clinical Lectures on Surgery" delivered by Dupuytren, published in 1832 by "An Association of Physicians," who were apparently his students, and from this volume it appears that Dupuytren's accurate knowledge and description of the condition was originally based on a postmortem dissection in a patient dying from an independent cause. Up to that time it was his belief, like that of his contemporaries, that the contractures depended upon tendinous or articular involvement, as the fascia had not been hitherto suspected. In this connection it is interesting to note that Dupuytren's first case was that of a wine merchant on whom he operated June 12, 1811, and

[1] Published in *The Post-Graduate*, August, 1909, and *The Medical and Surgical Reports of Bellevue and Allied Hospitals*, vol. iv, 1909–10.

by making multiple minute subcutaneous incisions he was able to obtain a good result. The condition was attributed by the surgeon to the patient's occupation so frequently requiring him to lift the edges of casks and barrels, thus producing more or less constant palmar pressure. This surgeon's next case was operated upon December 15, 1811, and in this instance the patient was a coachman with a well-marked bilateral affection attributed to his occupation. Mention is made of the poor general physique of the patient in explanation of the fact that only the right hand was operated upon, and that a poor result was obtained by the author's method of subcutaneous division. After operations of this type Dupuytren insisted that a dorsal splint be worn several weeks, and his cases were apparently much benefited in many instances.

In 1834 Gayraud, of Aix, as a result of dissections, in the main agreed with Dupuytren as to responsibility of the palmar fascia, but he thought that the lateral prolongations of the latter belonged to the disease and were not anatomic.

In 1864 a patient of William Adams, of London, who had declined operation for his bilateral contraction of the fourth and fifth fingers, met with an accident by which ". . . the contracted fingers of the right hand were suddenly torn open, and the skin in the palm torn across. . . ." There was a quadrilateral gaping wound in the palm exposing the transversely torn palmar fascia, but the tendons were intact. This surgeon excised a few torn strands of the fascia and was able to extend the previously contracted fingers, and he sutured the wound in the skin and splinted the fingers. He ends the narration of the case by stating " . . . the healing process proceeded without interruption, and the fingers remained nearly straight without their power of flexion being lost; . . . he has since died, but no recontraction had taken place. . . ." This surgeon in 1879 published a small book on "Contractions of the Fingers," and in 1892 a second revised edition of the same work, the publications being based on lectures delivered at the Royal College of Surgeons. He gives credit to Stromeyer for calling attention to the subcutaneous method of treatment in 1831, but says that Delpech in 1816 first suggested subcutaneous methods, although for other purposes.

In 1875 Madelung reported the value of the open method of operation as performed by Busch at Bonn. Sir William Ferguson did a linear dissection of each contracted band, making a transverse incision at the constrictions. In 1876 Professor A. C. Post, of this city, did an open flap operation. In 1879 Adams published his method of

multiple subcutaneous divisions with a special scalpel. In 1884 Abbe, of this city, read a paper at the Academy of Medicine in which he advanced a very ingenious reflex nervous theory of origin based on the following working hypothesis, which I quote in his own language:

"*First.*—A slight traumatism to the palm often entirely forgotten.

"*Second.*—A spinal impression produced by this peripalmar irritation.

"*Third.* -A reflex influence to the part originally hurt, producing insensible hyperemia, nutritive tissue disturbances and new growth, shown in the contracting bands of fascia and occasional joint lesions resembling subacute rheumatism.

"*Fourth.*—Through the tense contraction, a second series of reflex symptoms, neuralgias, general systemic disturbances, and a reflection of the trouble to the corresponding part of the opposite hand."

In 1886 he reaffirmed the same theory, and again in 1894 in his "Carpenter Lectures" at the New York Academy of Medicine on the general subject of "The Surgery of the Hand." Under date of June 13, 1909, Dr. Abbe writes me that this original theory ". . . seems as plausible as any yet given. . . . The origin is still an unsolved puzzle. There are some cases traceable to traumatism, but not many. There are some which have marked neuroses, but most compel some research to elicit the connection between the neuralgia and the hand lesion. This remark applies to so many surgical conditions that the absence of marked neuralgia in most is no proof of its not being present. . . . It is more absurd to call it a rheumatic condition than a neurosis. If it be not the latter, I do not know what is the causative factor."

This hypothesis does not seem to have been given much weight, apparently because the pathology on which it is based seems so speculative that it is difficult to conceive of a "spinal impression" registered by an almost forgotten slight trauma to the palm. Keen (who has written much on the subject), quoted in agreement by Adams, says: "Abbe's theory of a nervous origin seems to me only probable in so far as gout or rheumatism are possibly nervous in their remoter origin."

This, then, briefly is the history of this interesting ailment, and it is worthy of notice that Dupuytren's original statement as to the seat of the lesion is universally accepted, and that his method of subcutaneous incision has still applicability in a certain class of case, although his observations are now more than three-quarters of a century old.

Anatomically the palmar fascia is a fibrous apron investing the palm of the hand subcutaneously, being separated from the skin by more or less fat, and acting as a protection and serving to hollow the palm in

flexion of the hand. It is divided into a *central* and *lateral* portion. This *central* main portion radiates fan-like from a narrow origin at the annular ligament; later it begins to divide on a level with the extended thumb, and there sends a fasciculus to each finger except the thumb. When each of these slips reaches the finger, it splits to pass into the lateral margins of the anterior ligament of the metacarpophalangeal joint, and smaller divisions pass to the skin at the furrow where the matacarpals and digits join, and also to the periosteum of the first phalanx. The *lateral* part of the fascia is accessory and thin, and radiates to the thenar and hypothenar regions, but it does not reach beyond the level of the extended thumb. This briefly described structural arrangement predisposes to contractures on the ulnar, and practically confers immunity on the radial, side of the hand.

Pathologically the condition is a sclerosis of ordinary type, and it has been aptly called "fasciitis" by Ledderhose, and the proliferation is said to take place in the arterial sheaths as well as in the individual fibrous bands. All grades of thickness are met with, and in old and well-marked cases the proliferations may be ½ inch or more in thickness and almost cartilaginous in consistency. In no instance are the tendons or their sheaths involved, nor are there changes in the articulations, periosteum, or bones unless the condition is very far advanced.

The *etiology* has always been a moot point and even now no uniformly adequate cause is known to exist. From the time of Dupuytren, trauma has been held to play a part, but no one has maintained that a single or isolated injury was productive, nor is such a theory tenable. The trauma held to be causative was that incident to occupations in which the palm of the hand was more or less constantly irritated, and hence coachmen, porters, soldiers, laborers, and others who did manual work were supposed to be especially liable. Dupuytren and many of his time believed repeated traumata to be the sole cause. Others hold to the view that gout and rheumatism are factors; others believed the condition to be of neurotic origin, in effect a dystrophy not unlike that seen in disorders of the central nervous system. All authors mention the fact that heredity plays a part, and that many members of a family in later years develop the condition irrespective of their occupation.

At the present time there are, then, several ascribed causes, but that trauma plays practically no part is my contention and the basis for bringing this matter to your attention. This belief hinges on the following facts:

1. *Rarity of the Condition.*—There are many physicians in active

practice who have never seen a case since student days, despite the fact that they number all classes of manual laborers as patients.

2. *Location of the Lesion.*—The vast majority of cases affect the ulnar border of the hand which is the part least susceptible from occupations requiring grasp, push, or pull—manual effort. Further, the left hand is affected almost as often as the right, although the latter is more often used. Again, it usually begins first in one hand, and then progresses to the other, and it is almost never symmetric when bimanual, and bilaterality itself is against traumatic origin.

3. *Absence After Destructive Injuries.*—Wounds of the palm are exceedingly frequent and often associated with infection of the tendons and their sheaths without producing contraction of the damaged intervening palmar fascia, which must, of necessity, take part in the surrounding inflammatory reaction.

5. *Period of Onset.*—The majority of the cases appear after the fiftieth year at a time when sclerotic processes elsewhere are in evidence and when manual labor has practically ceased.

6. *Absence in Plantar Fascia.*—The sole of the foot is constantly subjected to pressure, but fascial contraction is exceedingly rare, although anatomically the plantar and palmar fascia are analogous.

7. *Occurrence in Non-laboring Class.*—Cases are frequently observed in mental workers, and of 220 cases reported by Keen, 49 were in manual and 74 in non-manual laborers.

It seems to me that if any occupation should predispose to this condition it would be motormen, who in their work for eight or ten hours daily fit the palm of the right hand on the rounded knob of a metal brake-handle and the left hand on the similarly shaped metal or wood controller-handle in the operation of trolley cars. I have spoken with physicians who have to do with the treatment of this class of employees and I have yet to hear of a case in which this contraction has been brought to their notice, even though some of their patients have been operating horse-drawn, cable, or trolley cars upward of twenty years. So far as the steam railway men are concerned, Dr. W. B. Outten, Chief Surgeon of the Missouri Pacific Railway Company, writes me that he has personal records of over 100,000 cases of injuries to railway employees, passengers, and others, and he has yet to see a case arising from trauma. Inquiry among the surgeons of the local transportation companies elicits the same fact; and personally, speaking from an experience of many years in the examination of those injured in local railway accidents, employees and others, I have never seen a case in which the contraction arose from injury or occupation, and I

can recall only two or three instances in which it was even alleged to have grown out of injury, and in these the claim was disputed and became the subject of litigation, proof being offered that the condition antedated the alleged accident. Likewise, inquiry among many visiting surgeons of general hospitals having to do with the treatment of the injured has brought a negative response to the inquiry as to whether they have ever known a case to arise from injury, and nearly all of these surgeons recall with difficulty ever having seen a case in hospital practice except as a deformity of passing notice.

These foregoing facts fortify the opinion that injury is not a producing factor, and the actual causation may yet prove to be a lesion of the central nervous system, perhaps toxic in origin. In this connection there is on record a case in which the bilateral contractures disappeared in a well-marked case after a seizure of cerebral hemorrhage. A similar remarkable case was also verbally related to me, but not in detail sufficient for recording purposes at this time.

While rheumatism and gout and occupation are frequently found in association with the disease, they appear to exist only as predisposing and not as actual producing causes, and cannot be looked upon as constant etiologic factors.

The **symptoms** are slow in onset and the usual primary stage begins as a painless puckering or more or less nodulation of the skin of the palm close to its junction with the fingers, usually near the base of the ring and little finger. This may be the sole symptom, and it may and frequently does persist in that degree for five or six years, although there are some few recorded cases in which after the lapse of a shorter period some contraction of the finger begins. When the finger becomes affected, the proximal phalanx and the one adjacent to it become involved, and the second or contracture stage is reached. This may affect one finger alone or may invade the adjacent digit; the usual order is for the ring finger to show the initial and most marked change, with or without involvement of the adjacent little finger. In 263 cases cited by W. W. Keen and Nichols, the ring finger was affected in 249; the little finger, in 194; the middle finger, in 93; the forefinger, in 24; the thumb, in 12. The same author says that in 223 cases the right hand alone was affected in 70; the left, in 35, and both, in 125 instances. Hoffa reports 1.59 per cent. of this contraction in 1444 cases of deformities; in 227 cases there were 180 men and 40 women. In 198 recorded cases heredity was a factor in 25.2 per cent. of patients. It is exceedingly rare in children; however, one case at six months and a few congenital cases are narrated.

In another class of case contraction of the finger at the metacarpophalangeal junction is the initial sign, the nodulation and puckering rugæ in the palm occurring as later manifestations. After the process has gone on in one hand to a moderate or greater degree, the opposite hand often becomes affected, usually to a lesser extent, but generally with involvement of corresponding portions. A well-marked case will show, then, contraction of one or more fingers (generally the fourth and fifth), with visible raised, tense, hard fascial bands reaching from the palm to the metacarpophalangeal joint like violin strings, with often transverse rugæ and nodules. In a severe case the fingers will be contracted sufficiently for the distal phalanx to touch the palm, the latter being irregular from numerous nodulations and rigid fascial strands. The distal phalanx can usually be extended, but the proximal and central phalanges are firmly fixed in flexion, but can be further flexed by relaxing the binding fascia, this being a differentiating sign.

From the beginning of the initial nodulation or contraction to well-marked deformity many years will usually elapse; and in certain cases two decades intervene before the contractures reach extreme grade, although all cases tend to get worse even after an apparently stationary period. There are a few cases seemingly acute in type, but the history in these is generally unreliable as to the actual initial symptoms because nodulation may exist a long time without comment, or be attributed to other causes (Fig. 433–435).

Treatment is unavailing by apparatus designed to forcibly correct the deformity, and operation is the only method affording more or less complete relief.

Two operative procedures are in vogue, namely, subcutaneous incisions and open dissection by longitudinal excision or by flaps. The method of multiple incision by a special tenotomy knife is that practised mainly by Adams, of London, who, as already stated, has had good success with this method, and he has many followers. He makes on the average six small longitudinal incisions at the sites of maximal contractures, and then transversely severs the binding fascia as completely as possible by successive nicks from above down, meanwhile extending the digit as he incises. In extreme cases he has made as many as twenty-three incisions, each designed to liberate a series of contracting fibers. He immediately applies a splint which is constantly worn until the wounds have firmly healed, and it is then gradually dispensed with. He first advocated this method in 1879; and, writing in 1892, he employed the same technic with modification only in so

far as he now advises immediate extension rather than seeking same gradually by splints after operation.

The flap method of Kocher, and others, dissects a triangular or quadrilateral section of skin from the palmar fascia and then excises the latter; or, following the method advocated by Keen, the initial incision includes the palmar fascia in the skin-flap and then dissects the fascia free from the skin by an incision that runs along the ulnar border from the inner part of the hypothenar eminence to the web between the ring and little fingers, thence transversely to the web

Fig. 433.—Nodulation and puckering.

Fig. 434.—Contraction of fourth and fifth fingers and nodulation.

between the index- and middle fingers, and thence upward to about the middle of the thenar eminence, this making a **U**-shaped flap, with the base well above the middle of the palm. After all the prolongations are released the fascia is dissected from the underlying skin, and the latter is sutured in place.

The flap method is the one of choice, especially in advanced cases, the disadvantage being that when the deformity is corrected there often remains a gap at the lower portion to be later filled by granulations; also because the lateral accessories of the fascia to the metacarpal and phalangeal regions are often hard to reach, and it is frequently impossible to divide them sufficiently to permit perfect extension, and not

infrequently sloughing of the flap ensues. The operative relief is usually prompt, although it may be incomplete, and there does not appear to be much chance of recurrence if the after treatment succeeds in keeping the fingers in their restored position, and if there is no secondary contraction of newly formed granulations. Splints (dorsal or palmar, or both) are worn for about two weeks, and then massage and passive motion are begun, soon to be succeeded by active motion designed to favor extension. In selected cases local anesthesia can be used by infiltration of the palm; and in some cases exposure of the median and ulnar nerves has been made and the dissection proceeded with after these nerves have been infiltrated by cocain or allied agents.

Fig. 435.—Dissection of contracted fifth finger.

The differential diagnosis is easy, as the main clinically allied conditions are those of so-called "hammer-finger" or "trigger-finger" and contractions of congenital, cicatricial, and tendinous origin. Each is readily excluded by the history and the distribution of the contraction and the absence of nodulations or superficial longitudinal palmar bands, and by the ability to overcome in some degree the existing deformity by manipulation.

In the absence of nodulations and longitudinal visible or palpable bands radiating from the palm, a diagnosis of typical Dupuytren's contraction should not be made, especially if the proximal and central phalanges can be extended.

CHAPTER X

FOREIGN BODIES

VARIOUS sections of the body are sometimes invaded by objects accidentally or purposely introduced, and while these are usually not immediately serious, their removal often requires considerable dexterity and ingenuity.

Foreign bodies may be metallic, like bullets, hooks, various kinds of pins, sections of instruments, or tools or filings.

Mineral bodies may be stone, cement, dirt, emery, or glass.

Vegetable matter, like beans, paper, or pulp, may gain entrance.

Animal matter, such as insects or their eggs, may find lodgment.

EYES

The superficial or deeper parts may be invaded, most commonly by small fragments of dust, coal, or metal; the depth of penetration is the index to treatment and outcome. Certain occupations, like mining and railroading, are actively predisposing; seafaring men and others exposed to wind are prone to pterygium and allied irritative conditions.

Superficial penetration is promptly followed by pain and signs of conjunctivitis, iritis, or keratitis, notably tear flow, some swelling of eyeball and lids, and injection of the membrane. The discharge later becomes purulent and the lids often are glued by secretion, and vision is temporarily affected.

Treatment is removal of the offending object either by boric acid irrigation or by direct contact of sterile gauze, or pointed instrument (toothpick or spud). If somewhat embedded, cocain or novocain solution (1 to 5 per cent.) is needed. Later, the inflammation usually subsides of itself or it may be aided by instillations of atropin (1 per cent.) sufficient to keep the pupil dilated (twice or thrice daily is generally enough). Argyrol (10 to 40 per cent.) is useful for controlling purulent discharge. Ice-cold or hot boric compresses will prove soothing.

In deeper penetrations and where particles are invisible to ordinary inspection or much embedded, an oculist should be consulted promptly.

This is notably true if there is much obvious damage to the iris or vitreous, as by bullets or shot. Signs of this sort of damage show as aggravated conjunctivitis, iritis, or keratitis. If not too deep, a spud or other sharp-pointed instrument may remove it under cocain or novocain; if removable, the further treatment is the same as the foregoing until inflammation subsides. Dark glasses, bandaging, or an eye-shade may prove comfortable. If metallic particles are present, a magnet may be the best means of removal. *x*-Ray localization is very valuable, but it requires much skill and training. Actual destruction of deeper parts may call for enucleation of the eyeball to prevent involvement of the opposite eyeball.

Purulent secretion is prevented from spreading to the opposite eye by sponging or irrigation directed toward the ear, or by wearing a watch crystal over the opposite eye attached to the nose, cheek, and forehead by adhesive as indicated in Fig. 16.

Burns from lye, lime, and other irritants are best treated by flooding the eye with boric or bicarbonate of soda (3 per cent.) solutions, and later an oculist is consulted if necessary.

Results depend upon the depth and degree of damage; if readily removable, sight will be unimpaired even though the damaged area shows ulceration. In extensive injury variable visual defects may persist. After enucleation, deformity is measurably prevented by a glass eye. Frequently ill-advised efforts to remove a foreign body results in prolonged inflammation from gonorrheal or other introduced infection.

Ears

Children are especially liable to insert beans, shoe-buttons, pieces of pencil, and other more or less oval bodies into the meatus. Their presence may be unsuspected until odor, discharge, deafness, and other signs of otitis become manifest. In many cases bloody discharge occurs from involvement of the drum or irritation of the lining of the canal.

Treatment.—Direct inspection is a prerequisite, aided by reflected light and a speculum. *Irrigation* with boric acid may float or force out the invader. Insects, when adherent, can be first killed by inserting a chloroform- or ether-soaked plug of cotton, followed by irrigation or instrumental removal. Instruments, like forceps or a bent probe (or same improvised from a hairpin) may be needed. *Incision* is practically never required.

Later the otitis is controlled by suitable boric or bichlorid irrigations; permanent damage is very unlikely.

NOSE

Shoe-buttons, beans, and wads of paper are often pushed into the nostril by children, and nothing is said until parental questioning seeks to account for odor, discharge, nasal plugging, and perhaps swelling and pain. Objects may remain long unsuspected and treatment for a long time vainly given for a "stubborn cold in the head" under such circumstances.

Treatment.—Inspection is afforded by reflected light and aided by the preliminary use of cocain or novocain. *Irrigation* with boric solution may effect removal by the front or rear of the involved naris. *Instruments* like forceps or bent probes passed beyond and around the object may be needed. Sometimes pushing may cause dislodgment into the throat. Later, suitable irrigations and perhaps wet dressings may be required.

THROAT

Food particles, or meat or fish-bones may find lodgment while eating, or be ingested during vomiting, especially during the unconsciousness of anesthesia or alcoholism. Coins and toy whistles are also occasionally swallowed. Symptoms may be urgent and choking imminent and apparent. Other cases show local pain and irritation while swallowing or talking, and are cough inducing.

Treatment.—Removal by hooking the finger around the morsel is successful in the urgent cases, and this is sometimes aided by head-down positions and violent coughing.

Fig. 436.—Improvised hairpin retractor for a tracheotomy or other wound.

Emergency tracheotomy is preferably performed by an incision above or below the isthmus, which in an adult lies between the second and third ring of the trachea; in a child it lies on or even above the first ring. The high (above isthmus) operation is preferable because intermuscular and more nearly bloodless, and the superficial position of the trachea.

Steps in high tracheotomy: (1) Head thrown backward as far as possible and held exactly in the median line. (2) Locate the cricoid and thyroid cartilages. (3) Incision begins at upper border of the cricoid cartilage and is carried downward in the exact median line 1½ inches, passing deep enough to penetrate skin, superficial fascia, and the anterior layer of the deep (cervical) fascia. (4) Separate the sternohyoid and sternothyroid muscles and divide the fascia over the trachea which comes now into view. (5) Steady the cricoid with a

hook or mouse-toothed forceps. (6) Push the isthmus downward if it gets in the way. (7) Plunge the knife in (blade facing upward) close above the isthmus in the exact midline and cut upward through two or three rings.

Retraction enough of the wound usually occurs instantly to permit breathing; if not, the wound may be retracted and kept open by improvised means, such as a twisted hairpin (Fig. 436) in the absence of the usual tracheotomy tube. The lower part of the skin wound is sutured and at a suitable time the opening is allowed to close.

Some of these cases subsequently develop so-called irritation or swallowing pneumonia, usually of the bronchial type; the onset of this is sometimes prevented by upright posture and vigorous counter-irritation to the chest by hot applications and cupping.

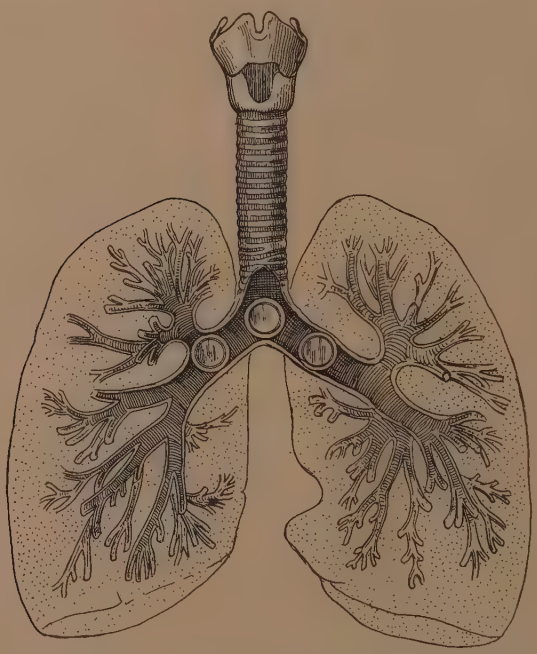


Fig. 437.—The bronchial tree; the circles indicate common sites of lodgment of foreign bodies.

Trachea and Bronchi

The windpipe begins on a level with the thyroid cartilage and extends to the bronchial division, which is opposite the space between the fourth and fifth dorsal vertebræ. The right bronchus is straighter

and less angulated than the left, and hence foreign bodies are the more often lodged therein (Fig. 437).

Occasionally portions of food are inspired and, if small, are forcibly expelled by coughing; other articles, like coins, false teeth, safety-pins, (Fig. 438), or toy whistles, become jammed and cause varying degrees of pain and respiratory difficulty with signs of tracheitis and bronchitis. The exact location of such objects is best determined by *x*-ray examination if too low for inspection through laryngoscopic or bronchoscopic examination.

Fig. 438.—Open safety-pin in trachea of a child.

Treatment.—Removal is effected by pronged forceps, hooked instruments, or others of the "coin-catching" type, perhaps aided by the bronchoscope in dexterous hands (Fig. 439). If thus irremovable, open operation is necessary, the incision being made as for a laryngotomy, thus: (1) Incision 1½ inches long in the midline from the lower border of the cricoid to above the lower edge of the thyroid. (2) Divide structures beneath; separate sternothyroid and sternohyoid muscles; cut the deep layers of fascia. (3) Divide the cricothyroid membrane transversely just above the cricoid, and insert tube.

Laryngotracheotomy opens the cricothyroid membrane vertically and the cricoid cartilage and upper ring of the trachea. The dangers

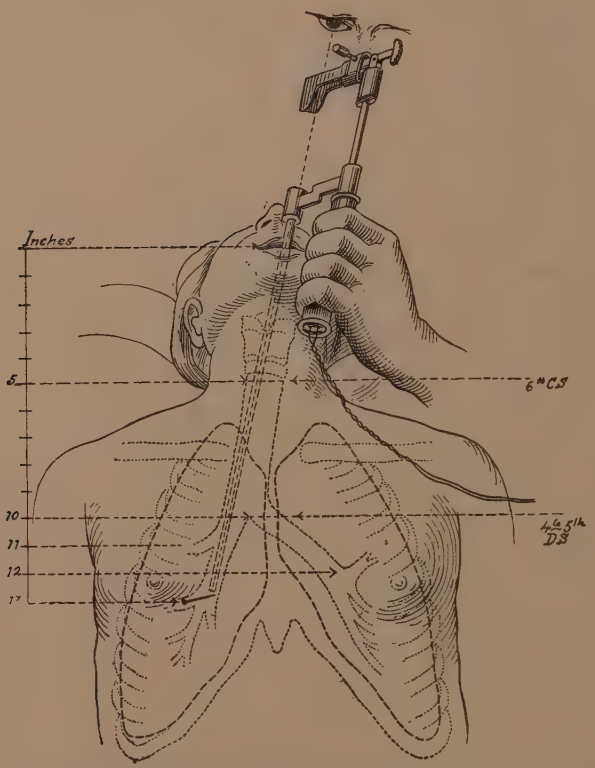


Fig. 439.—Bronchoscope seeking a pin in the right bronchus. The numerals denote the relative length and position of respective portions of the upper respiratory tract in relation to the teeth and vertebræ.

of pneumonia and abscess are greatest when the object is low down, firmly wedged, and when tissue damage is increased by removal.

LUNGS

Objects that pass the bronchi and reach the lung (usually the right lobe) may become more or less encapsulated and cause no symptoms; frequently, however, signs of bronchitis, pneumonia, abscess, or gangrene appear, and are regarded and treated as of non-traumatic origin, especially when the foreign body is forgotten or supposed to have been expelled. I know of a case in which a clergyman swallowed a tooth and subsequently developed a cough and other signs of lung irritation that later subsided, and he supposed he was rid of his unwelcome

guest; still later, while delivering a sermon, a violent fit of coughing resulted in the production of the missing tooth. Localized abscess of the lung is so commonly due to inspired foreign bodies that *x*-ray examination should be made early in this class of cases. Patients have even been treated for phthisis until radiographs demonstrated abscess due to a foreign body focus.

Treatment.—Removal by thoracotomy is necessary, preferably under negative pressure, or the intratracheal insufflation method of Meltzer and Auer and others. Foreign bodies entering through the chest wall are mainly *bullets* and *drainage-tubes*. Drainage-tubing is occasionally brought within reach of an empyema or other opening by irrigation, or is fished for with forceps with previous *x*-ray localization preferably. In one case I recall that a member of the Harlem Hospital house staff recovered the tubing in an empyema case through the inspection afforded by the urethroscope (Fig. 440).

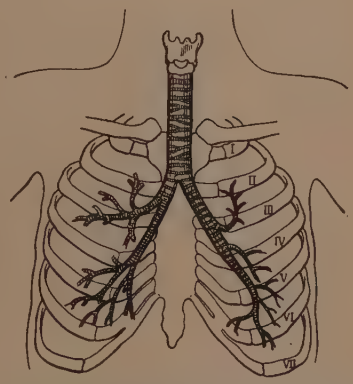


Fig. 440.—Relation of the bronchial tree to the ribs and chest wall.

The **outcome** in this class of cases obviously depends upon the extent and duration of the process, but in all it is problematic if abscess formation has occurred.

ESOPHAGUS

The gullet is about 10 inches long and begins at the lower border of the cricoid cartilage (between the sixth and seventh cervical vertebræ), and ends below the diaphragm opposite the tenth or eleventh dorsal vertebræ. Food is the commonest source of obstruction, and this may be a large bolus, or a fish or meat bone. Occasionally children and others swallow marbles or keys and other objects; pins, glass, and coins form another group. Most foreign bodies are arrested about 6 inches from the incisor teeth, about opposite the lower edge of the cricoid and the sixth cervical vertebra, where the diameter of the gullet is approximately $\frac{1}{2}$ inch; this point is practically the beginning of the tube. Another constricted region is 4 inches below the preceding, where the left bronchus crosses. A third zone is at the diaphragmatic opening, which is approximately 15 inches from the incisors.

Symptoms.—These are chiefly irritative, such as localized pain and a "feeling of fulness" and difficulty in swallowing, and sometimes dyspnea; in completely obstructed cases even water is rejected. If the invader is sharp, blood may appear on coughing or vomiting. The exact location of blocking may be determined sometimes by palpation or the patient's gestures; in other cases diagnosis depends upon the bougie or *x*-rays.

Treatment.—Removal by forceps, the bronchoscope, or esophagoscope may be effective in some cases; in others the obstruction may be pushed into the stomach. These means failing, esophagotomy and removal by direct inspection is necessary, preceded by *x*-ray localization. If lodgment is above the lower third of the tube, *external esophagotomy* is performed through an incision on the left side between the trachea and larynx in front and the carotid sheath behind, the cricoid cartilage being the level of the middle of the incision. After opening the gullet and extracting the invader, the mucous membrane is sutured with catgut and the external parts are drained. If the foreign body is lodged in or below the lower third, then gastrotomy is performed. If there is impaction, the passage of a string from above may cause it to become entangled and thus permit it to be pulled into the stomach.

Outcome is favorable where removal is prompt. Complications, like abscess, stricture, or perforation, are relatively rare.

Stomach

The normal position is subject to considerable variation, but the upper or cardiac opening is usually on the level of the sixth left costal cartilage; the lower orifice is at the level of the eighth or ninth right costal cartilage.

Foreign bodies in some instances are long tolerated without symptoms; in the majority of cases some signs of gastritis exist and the vomitus or stools may contain blood. All sorts of objects are swallowed, notably coins, pins, hair, and keys. Hysterics and the insane may swallow objects of such size as to cause wonder and surprise at the dilatability of the esophagus; indeed, professional "sword swallowers" and others of that class may be veritable museums.

Symptoms of an acute sort usually subside after the object has traversed the esophagus; later, signs of gastritis may appear and there is likely to be pain and loss of weight. Determinative diagnosis generally depends on *x*-ray examination in old or suspected cases.

Treatment.—Objects capable of passing through the esophagus are

usually later expelled by rectum; it is, however, unwise to hasten their progress by cathartics, fearing that excessive peristalsis might result in intestinal perforation.

Gastrotomy is occasionally required, and the incision for this is through the midline or middle of the right rectus muscle a few inches below the free border of the ribs. The stomach is brought out of the abdomen and transversely incised on the anterior border midway between the curvatures, and then the interior of the organ is explored. Closure is made in the usual way.

INTESTINES

Very rarely obstruction occurs from a swallowed object that has passed the tract above; less often ulceration or perforation results. Objects are occasionally introduced per anum either for punishment or pleasure.

Symptoms are those of colitis or varying degrees of obstruction, with the pain quite likely to be localized. The exact site of the offender is often apparent by *x*-ray examination. Rectal palpation or information gained through the proctoscope determines the diagnosis in case the object has been introduced per anum.

Treatment.—If symptoms are non-urgent, a waiting policy is advisable, as the normal peristalsis may be spontaneously effective and harm may be done by active catharsis. Cathartics or high irrigation are effective in the majority of low colon cases; others may need enterotomy. Rectal foreign bodies are removable by forceps, with or without prior dilatation and the aid of the proctoscope.

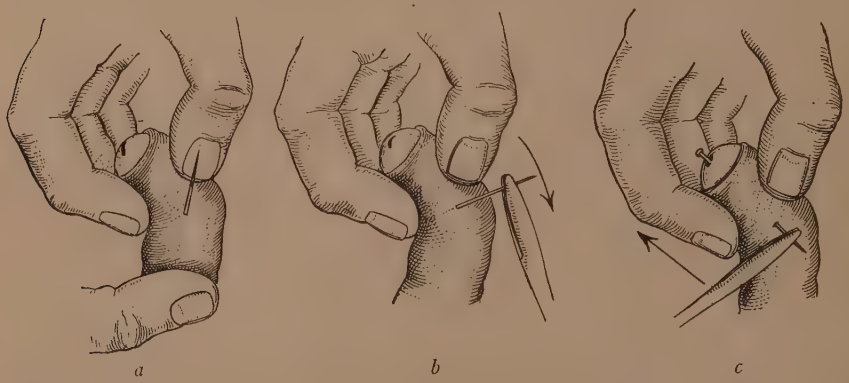
URETHRA

The female and male urethra often harbors foreign bodies, and most cases are the outcome of attempts at sexual satisfaction, and then the introduced objects are likely to be more or less cylindric. Rubber tubing, catheters, pencils, hat and other pins are commonly used.

Symptoms are pain, swelling, dysuria, hematuria, or anuria. The blockading object is usually visible or palpable. In boys, a swollen penis, strangury, and discharge may be the signs, where the object is too small to be seen or felt.

Treatment.—Removal is often quite a problem. Some objects are easily extracted by forceps and others are accessible enough for urethroscopic removal. Care must be taken to prevent pushing the substance into the bladder; this last, however, may be done designedly

in some instances. Occasionally a pin is removable by causing its point to penetrate the outer urethral wall and extrude through the



a *b* *c*

Fig. 441.—Removal of pin from urethra: *a*, Sharp end extruded; *b*, sharp end depressed; *c*, blunt end pushed through meatus.

skin; then it is manipulated so that the head of the pin is pushed toward and through the meatus (Fig. 441).

BLADDER

Females more than males present foreign bodies in this viscus, doubtless due to the shorter urethra. Pins of various kinds are often introduced; likewise pencils, candles, and various other objects. Accidentally, catheters, pieces of instruments, or thermometers may gain entrance.

Symptoms are those of cystitis, and the object may even go on to calculus formation or be unsuspected unless a history is forthcoming. In some cases hematuria, dysuria, and even retention will be marked. The passage of sounds, cystoscopic or *x*-ray examination may be the diagnostic factors.

Treatment.—Removal may sometimes be possible by the aid of forceps, with or without previous crushing or alteration in shape. Cystoscopic aid is very valuable and *x*-ray examination is also often useful. Suprapubic incision to accomplish removal may be necessary.

VAGINA AND UTERUS

Catheters, long pins, pencils, and other more or less cylindric objects are often introduced to produce sexual excitement or abortion. Children and others occasionally rupture the hymen in efforts to introduce objects into the vagina.

Symptoms.—In the absence of history, vaginitis and endometritis may long exist and be readily enough ascribed to other causes. Later, purulent discharge and odor may arouse suspicion, and finally a true history may be elicited.

Treatment.—Removal is usually easy from the vagina unless ulceration exists, and then incision to free adhesions may be needed. Wide cervical dilation and the use of broad forceps or the dull curet usually are successful in removing foreign bodies from the uterus. Vaginal or uterine irrigations are generally necessary before the resulting irritation is relieved. Laparotomy is only required rarely.

CHAPTER XI

INJURIES OF THE HEAD

When direct violence is applied to the cranium a variety of symptoms may appear depending upon: (1) Nature and extent of the violence. (2) Place of the receipt of the violence. (3) The individual: notably as to age, cranial conformation, sobriety, general physique, previous illness, and family history. (4) Treatment.

In a general way head injury may produce (*a*) *extracranial;* (*b*) *intracranial;* (*c*) *extra-* and *intracranial* effects. In this respect cranial injuries resemble those of the thoracic and abdominal cavities.

Extracranial Forms

These refer to *contusions* and *wounds* of the *soft parts*, but no special mention need be made of all of them, inasmuch as the causes, symptoms, treatment, and outcome resemble similar injuries elsewhere.

CONTUSIONS OF THE SCALP

These are prone to be localized or circumscribed, producing the very common condition known as "hematoma of the scalp." This is the outcome of a blow or fall, whereby the brunt of the violence is sustained over a circumscribed area which promptly swells from the subcutaneous effusion of blood (generally venous); such a condition is frequently referred to as a "bump on the head." This swelling may be quite large, and is most often seen on the front and lateral margins of the scalp where the soft parts are relatively lax.

In hairless regions the bruised skin is at first reddened and later becomes dusky blue, and in the end this color fades into a yellow mottling as absorption progresses.

Such a collection of blood may appear: (1) under the skin; (2) between the muscular fibers; or (3) between the latter and the skull (Fig. 442). The first form is commonest. The condition typically occurs at birth due to pressure along the parturient canal or from delivery forceps, the well-known caput succedaneum then existing; it is also known as hematoma neonatorum, and is frequently massive and deforming, but almost invariably disappears within a few weeks.

Sometimes hematoma of the scalp is accompanied by concussion of the brain, and a depressed fracture of the skull may be suspected because most of these collections of blood are depressible in the center and give the sensation of a skull indentation. The differentiation between depressed fracture and hematoma is made by noting that the edges of the latter are usually smooth and rather regular at the circumference, and that the change from the normal edge of the skin is rather abrupt. In fractures the edges are rough, irregular, and sloping. Careful pressure or massage over a hematoma will ordinarily push aside any indentation at its center, but there is no such shifting of a depression due to fracture. Very rarely the conditions may coexist, but then other signs of fracture are ascertainable.

Treatment.—*Pressure* causes absorption in practically all cases, and for this reason a cold-water compress (alcohol or lead-and-opium

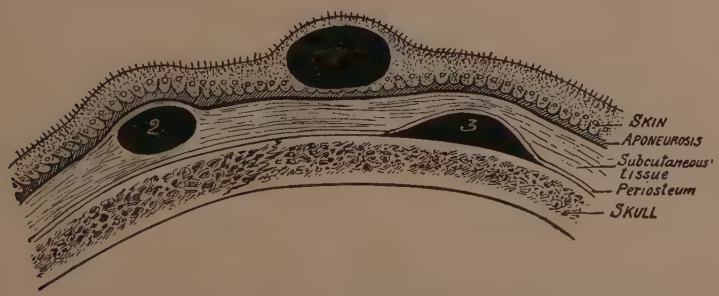


Fig. 442.—Sites of hematoma of scalp: 1, Subcutaneous; 2, subaponeurotic (or subfascial); 2, subperiosteal. (After Eisendrath.)

lotion may also be used) and a tight bandage are all that are needed. Massage is also an aid. In some rare cases aspiration of the "congealed" blood may be needed; less often incision is required. Before doing either of these, the operative zone should be prepared aseptically, lest infection converts a simple affair into a troublesome abscess or sinus. When a depressed fracture cannot be reasonably excluded, incision should be made and actual inspection afforded, aided by the introduction of a sterilized glove finger. In the event of incision, a small drain is advisable for a day or two.

SCALP WOUNDS

These are exceedingly common and may be of the same variety and origin as any other wound elsewhere. Their depth and extent vary according to the inflicting source and the place of receipt. Superficial wounds may bleed quite freely in certain locations, notably over the

lateral and frontal portions. If they extend to the fascial or muscular layers, gaping usually occurs. If the wound is "down to the bone" the periosteum is likely to retract, and sometimes is rough or ridged enough to feel like a crack or fissure in the bone, and often is thus mistaken for a fissured or linear fracture unless inspection or further palpation discloses the real conditions.

Treatment.—Cleansing is best accomplished by first disinfecting the wound and the surrounding region by flushing with tincture of iodin. The hair about this relatively sterile area is then cut or shaved enough to leave a bald area about the opening, and grease and dirt and foreign matter are removed by benzine, gasolene, kerosene, or olive oil. The part is then dried and iodin is reapplied; thus a relatively sterile field is provided. *Suture* and *drainage* are to be used in all cases in which the edges are not too seriously crushed or otherwise devitalized; in such an event no suturing is advisable. Catgut, horsehair, silk, linen, or silkworm-gut may be the selected material (Fig. 443). Metal clips in my experience induce ulceration. Drainage need not be extensive in relatively clean cases, but *all should be drained.* A few twisted strands of the suture material are placed at the lowest angle of the wound in "clean" cases, and they can be removed within forty-eight hours if infection does not appear. In other cases a twisted or folded piece of gutta-percha (rubber) tissue or a rubber band may be inserted in one or more places along the wound line. Gauze makes a poor drainage material, as after a few hours it acts as a cork or plug because of super-saturation.

Fig. 443.—Strands of hair used as improvised sutures to coapt a scalp wound.

Interrupted is better than continuous suturing, because if infection occurs in one part of the wound, all the stitches will not break down or demand removal.

If possible, the periosteum should be sutured separately; but the other layers are generally embraced and coapted in the grasp of one deep suture that also affords hemostasis.

Erysipelas is less likely to develop in the scalp than in the face; if it occurs, wet dressings of saturated solution of magnesium sulphate may be employed. A 20 to 50 per cent. ichthyol ointment is also frequently used.

BONE INJURY

This has previously been discussed under Skull Fracture (see page 239).

INTRACRANIAL FORMS

These comprise those (1) with skull fracture; (2) without skull fracture. Those *with skull fracture* have been mentioned under Skull Fracture (see page 239). *Without skull fracture*, head injury may result in concussion; compression; contusion and laceration; meningitis; encephalitis.

CONCUSSION (COMMOTIO CEREBRI)

This is a condition usually due to a direct or transmitted blow upon the head, and it is characterized clinically by *immediate* but *temporary* unconsciousness associated with vomiting and signs of shock, such as pallor, cold extremities, depression of the heart, and respiration.

Pathologically, there are few if any gross lesions; but occasionally minute hemorrhages are found in the cortex and brain substance.

Causes.—It is the commonest of all manifestations of head injury inasmuch as to some degree it is associated with nearly every accident to this part of the body.

Direct violence is the causative factor generally, such as blows or falls on the head due to a wide variety of accidents. *Indirect violence* is an infrequent source of origin; arising in this manner the impact is generally transmitted to the head from a hard fall on the feet or buttocks or a blow on the jaw.

Varieties and Degrees.—Three are manifested clinically: (1) Mild; (2) moderate; (3) severe.

Symptoms.—Obviously these are dependent upon the preceding grades of severity:

(1) *Mild forms* show some giddiness, staggering, nausea, and mild shock. The patient may merely "see stars" and ordinarily does not fall if the violence is due to a blow, as from a fist or walking against the edge of a door.

(2) *Moderate forms* are aggravations of the foregoing, and the patient is temporarily unconscious and is generally "knocked out" and may take several moments to "come to." Nausea and vomiting occurs and sufficient shock may exist to require aid in rising or standing. Occasionally some stimulation is required, but if given by mouth before vomiting has occurred, it is usually promptly ejected.

From just prior to the receipt of the violence until the senses are regained, memory ordinarily will be a blank; in many cases the victim will assert that he "does not know what hit him." Unsteadiness of gait, weakness, and some prostration may last several hours, and in some cases even a few days. Headache, with soreness and stiffness of the neck muscles, may persist a week or more. Vertigo and various ocular and auditory subjective sensations may also be asserted during the same interval. Marked irritability or apathy sometimes occurs.

(3) *Severe forms* show complete unconsciousness and marked shock, and often the bowels and bladder are involuntarily emptied. The duration of unconsciousness varies and it may last for hours; when the patient arouses, vomiting occurs, often in a projectile manner. Return to consciousness is generally gradual, but may be abrupt. Motor power is usually regained last and until then aid is needed in standing or walking. Patients may remain comatose and die in this stage.

The vast majority of the recoverable cases show what might be called a *period of depression*, in which the unconsciousness is the main symptom; and a second period of *irritation* or *reaction*, in which irritability, excitation, or apathy predominate.

It is to be remembered that true concussion is a state of *immediate temporary unconsciousness* only, and that periods of relapse or secondary unconsciousness ("partial coma" or "semicoma") take the case out of the typical concussion class.

Treatment.—*Mild degrees* require little if any treatment. Aromatic spirits of ammonia, whisky, or brandy may be given if necessary. The headache is relieved by a cold-water compress, and occasionally an ice-bag may be helpful. Anodynes or hypnotics may be advisable for a few days. Usually a few hours of rest is all that is required.

Moderate degrees require rest in a prone position and occasionally stimulation by whisky, strychnin, adrenalin, or camphor. An ice-bag or cold-water compress is useful for headache. A brisk cathartic is advisable and the diet is limited for a few days. When the pulse and temperature are normal for two or three days, the patient is allowed to get out of bed and the next day is permitted to walk, and soon is allowed to return to work if objective symptoms are lacking and the subjective symptoms are not unusual.

Severe degrees usually demand hypodermic stimulation, but this is withheld unless the pulse indicates need of support. *Shock* is combated in the usual manner, but main reliance is placed upon absolute rest in bed. No strenuous efforts should be made to arouse the patient, as these are not only ineffectual but also are dangerous,

because the unconsciousness of itself is no measure of the gravity of the condition.

In old people, frequent change of position is needed to forestall hypostatic changes. When those of alcoholic type regain consciousness, bromids and chloral should be given if there is restlessness or tremor of the tongue or fingers indicative of impending delirium tremens. *Headache* is best treated by an ice-bag.

Rest is all important, and these patients should be kept in bed until symptoms are abated. Pain in the head and vertigo, especially on exertion, are sometimes complained of for a long time.

Diagnosis.—Differentiation is to be made from syncope or fainting, shock, and comatose states, such as might be due to alcohol, drugs, nephritis, apoplexy, diabetes, and other non-traumatic conditions.

The preceding history of the case is very important, as in some instances there may be an initial coma from a non-traumatic source, and yet a fall may be the only *apparent* cause for the condition in which the patient was first found. This is especially likely in alcoholics, nephritics, and apoplectics, who often fall, striking on the head, at the onset of coma from the preceding condition, and the first inference is that the injury and not the antedating constitutional trouble is at fault. In some of these cases an operation or autopsy may be the final deciding evidence. It is to be recalled that central hemorrhage is never traumatic, but cortical hemorrhage is rarely due to anything but injury.

Results.—These cases get well, but in severer grades recovery may be attended by decreasing subjective complaints, notably headaches, vertigo, unsteadiness in gait or station, and alterations in the auditory and visual mechanism.

CONTUSION AND LACERATION OF THE BRAIN

By these may be implied that series of effects somewhat more advanced than in concussion and less marked than in generalized compression. The extent of bruising may vary to such a degree that many regard contusion only as a form of concussion, and laceration is described as an independent entity. There is some confusion among writers as to this classification and differentiation, but clinically the following seems adequate:

Contusion means a bruising of the brain with definite extravasation of blood in variable amounts; if large extravasations occur there is *generally* some associated tearing of the brain tissue, and then *laceration* is said to exist.

Causes.—Violence of the *direct* or *indirect* type is generally productive and a fracture of the base of the skull often coexists. Localized violence—such as bony depressions bullet and stab wounds—is also a factor.

The commonest sites of contusion and laceration are the regions lying near the middle fossa, and the tips of the temporal and base of the frontal lobes. Violence applied at one pole of the skull, yet affecting the opposite pole, sometimes produces contusion or laceration by the so-called *contrecoup*.

Sixty per cent. of deaths in the first twelve hours in 470 cases of skull fracture were due to contusion (most marked in the cerebellum), according to Eisendrath, quoting Brun's (Heidelberg) statistics.

Symptoms.—There are several groupings: (1) The *cortex* is ordinarily involved in that group in which basal fracture is absent, and hence cortical irritative signs are promptly present, such as twitchings or localized spasms of a limb or portion of the face; later, paralysis of the part may occur. Concussion and compression signs generally coexist and meningitis or encephalitis may appear subsequently. (2) Localized involvement of the cortex with transitory or no signs of concussion or compression. Motor aphasia is a common manifestation in this group. (3) Advanced results of concussion and compression with paralysis more or less marked.

Diagnosis.—In a general way it may be stated that symptoms of contusion and laceration are more pronounced and lasting than concussion, and, in addition, signs of cortical irritation usually give further differentiating signs. Lumbar puncture frequently elicits blood.

Treatment.—This is practically that of the advanced grades of concussion in the absence of focalizing signs warranting operation.

COMPRESSION

By this is meant pressure within the skull, circumscribed or general, of such a grade as to produce variable local or systemic signs, depending upon the nature, extent, and duration of the pressure.

Causes.—*Direct violence*, as from blows or falls on the head, is the cause in practically every traumatic instance, and the majority of cases are associated with fracture of the skull, often of the depressed variety. *Indirect violence* is a relatively rare factor.

Varieties.—*Intracranial pressure* and *tension* may be due to many causes aside from injury, but the following are clinically inclusive for traumatic sources:

Bone: Fractures of skull.
Blood: Intracranial hemorrhages, contusion, and laceration.
Serum: Intracranial edema.
Pus: Intracranial abscess.
Foreign bodies: Intracranial bullets or other missiles.
New growths: Intracranial cysts or other neoplasms.
Meningitis: Serous and purulent.
Encephalitis.

Determining Elements.—There are two basic factors dependent upon the type of the pressure, namely: (1) Local increase in intracranial tension; (2) general increase in intracranial tension.

(1) *Local Intracranial Tension.*—This occurs when pressure is exerted upon an isolated or circumscribed area of the brain, as from a spicule of bone, blood-clot, abscess, or foreign body.

Most traumatic cases are examples of this variety.

The effects are directly dependent upon the site of the pressure, its amount, and duration. Obviously, the greatest effects are felt nearest the seat of the pressure, and the nearer this is to the vital basic centers, the greater the systemic effect imposed.

(2) *General Intracranial Tension.*—This occurs when pressure is exerted upon the entire cerebrum, as from a large extravasation of blood or serum, meningitis, hydrocephalus, or edema of traumatic or systemic origin.

Apoplexy is the best example of this type, and relatively few cases of this class are traumatic.

Obviously the *duration* of the pressure or tension is important, as it is well known that slowly increasing pressure (as from abscess or tumor) may give few, if any, symptoms at first, whereas an acute or sudden onset of pressure (as from cerebral hemorrhage or a bullet) usually gives pressure manifestations at once.

When pressure is exerted over any area of the brain one of the earliest effects is adjacent *venous stasis* and diminution of *cerebrospinal fluid*. If pressure still continues and reaches the point where it equals that in the capillaries and arteries, a condition of *cerebral anemia* then results, with loss of function in the area robbed of its blood-supply. In some cases where pressure over the medullary centers equals the arterial tension the resulting anemia stimulates the vasomotor center and the general arterial pressure is raised, and thus the medullary centers continue to act (Cushing). This same condition may be repeated if the pressure still continues, and thus general arterial tension may be increased markedly; in other words, there is the familiar "rise

of blood-pressure." This progressive rise in the circulating arterial blood is due to constriction of the splanchnic field, and, when it is fluctuating, respiration of the Cheyne-Stokes type appears and may continue for hours (Cushing). If, however, cerebral pressure continues to increase, arterial pressure finally fails to respond, medullary anemia results and the respiratory center fails, and finally the heart ceases to beat.

The foregoing statement aims to show that the essential influence is not mechanical or structural, but is due to the anemia of the medullary centers resulting in the *major* or *bulbar* symptoms of compression, which may be said to be:

(*a*) *High blood-pressure* from stimulation of the vasomotor center.

(*b*) *Slowed pulse* from stimulation of the vagus center.

(*c*) *Cheyne-Stokes' respiration* from the fluctuating level of raised arterial tension mentioned above.

Symptoms.—Having in mind the preceding *determining elements*, it follows that the signs will depend upon the *site*, *extent*, and *duration* of the pressure.

It is stated that before signs of general pressure exist there must be a displacement of over 6 per cent. of the brain mass (Archibald, in *Amer. Practice of Surgery*).

It is to be remembered that the preceding history is of great importance, especially that portion of it relating to the progress or "march" of the symptoms.

In *conscious* and rational patients careful inquiry may elicit the history of immediate unconsciousness after the injury, with subsequently a period of apparent recovery, during which the patient felt well aside from variable subjective complaints. This practically means a history of concussion; however, following this "latent period" or "free interval," symptoms recurred, and this sequence brings the case into the compression class. In *unconscious* or irrational patients a history of value is often unobtainable from friends or witnesses, and the diagnosis then depends largely on the examination alone.

Ordinarily *four stages* are described, following out the classification of Kocher and Cushing:

First Stage, or Stage of Compensation.—This mildest form produces few if any signs unless the pressure is in the vicinity of the medulla. Ordinarily the signs are not unlike those of the postconcussion type; namely, headache, giddiness, mental inaptitude, and very occasionally some few temporary focal signs affecting a limb or special sense.

Second Stage, or Stage of Manifest Beginning Compression.—The

foregoing signs are exaggerated and congestion of the upper part of the face may be marked enough to produce *cyanosis*. The superficial veins may be *turgid*. The *eyes* are congested and the ophthalmoscope may show some beginning *edema* of the *optic nerve* (papillary edema). The *pulse* is generally *slowed* and the *blood-pressure* may be elevated. Signs of meningeal irritation with restlessness or irritation prevail.

Third Stage, or Stage of Acme of Manifest Compression.—Here there are more wide-spread evidences of capillary anemia and medullary signs are now apparent, and, as Cushing puts it, the fight is well under way on the part of the medullary centers to withstand the crushing effect of the compressing force.

Paralysis of varying degrees occurs, the location of greatest pressure determining the site of the paresis. *Cyanosis* is marked. *Respiration* is ordinarily increased at first, and later is stertorous and may become Cheyne-Stokes' in type. *Pulse* is slowed (40 to 50) and the volume is increased and may be "full and bounding"; the rate may not be slowed even in this stage, or in the presence of fever or shock. *Blood-pressure* increasingly rises. *Unconsciousness* (probably due to cortical anemia) will be partial or complete, and it may be associated with the delirium and marked irritability formerly held to be so diagnostic of cerebral laceration. *Reflexes* are abolished. *Optic edema* is marked and the condition of "choked disk" approaches.

Fourth Stage, or Stage of Paralysis.—Paralysis is complete and flaccid. *Respiration* is increasingly embarrassed. *Pulse* becomes rapid and weak. *Coma* is deepened. *Pupils* widely dilated. *Blood-pressure* falls. The patient is dying, but even after respiration ceases the heart may beat for some time.

In the later stages spinal tapping shows fluid under pressure, perhaps mixed with blood.

Differential Diagnosis.—*Injuries.—Concussion* and *contusion* are the two conditions most likely to be confusing.

Concussion presents unconsciousness as the essential, immediate, temporary sign; if there is recurrence or progress of symptoms, it is not concussion any longer.

Contusion is likely to give signs of immediate focal localization with or without evidences of concussion.

Compression is essentially a later manifestation with progressive signs delimiting more or less sharply into the respective stages.

Diseases.—Apoplexy, alcoholism, nephritis, gas-poisoning, and other coma- and paralysis-producing causes are usually capable of being excluded by the means previously named.

Treatment.—The main indication is to relieve the compression by (*a*) removal of the originating cause; (*b*) reducing the intracranial tension.

(*a*) *Removal of the cause* obviously only applies to those cases in which the tension is dependent upon some circumscribed or accessible source, like depressed bone, clot, serous collection, or foreign body; in other words, relief in this class is possible when the origin is relatively superficial, generally when there is "local increase of tension." The methods to be used will be described in connection with the treatment of Focal Pressure (see page 474).

(*b*) *Reducing the Intracranial Tension.*—This applies to that large group of cases of extensive fracture of the skull involving vault and base alike, associated with extensive bleeding and consequent pressure. It also includes that group in which there is a large dural clot, or any case like central apoplexy in which there is "general intracranial tension."

Relief in either of these contingencies depends upon reduction of the blood-pressure, and in traumatic cases there are practically few methods of accomplishing this satisfactorily. The best means is by *decompression*, and this is done preferably by the *subtemporal decompression method* so strongly advocated by Cushing. In performing this operation, incision is made after the manner stated in Fracture of the Skull (see pp. 260, 261). The temporal muscle is then separated in the direction of its fibers so that the underlying skull is exposed. A trephine opening is now made and a 25-cent-sized button of bone is removed, exposing the dura, which usually bulges promptly into the opening. It is generally lusterless and non-pulsating. If so, a rongeur forceps is used to increase this original trephine opening, generally in a downward direction, until it is as big as a dollar or more. The dura is then incised in a semicircular direction in such a manner that the dural incision does not come within ½ inch of the rim of the trephine opening, in order that no adhesions of it to the bone may later occur. Cerebrospinal fluid under tension may escape and the brain may bulge into the opening.

Careful note is to be made of changes in the pulse and respiration during the operation, and generally improvement will be noted on removal of the button of bone.

In most cases anesthesia is not needed. In some few cases it may be possible to suture the dura, but in most this is not feasible on account of the great tension. In such a contingency a pad of fat, muscle, or fascia may be interposed. The retracted muscle is then

allowed to fall into place and a few strands of twisted catgut or silkworm-gut or a thin rubber tissue (gutta-percha) drain leads down to the dura, and is brought out between the muscle at the lower angle of the wound. If necessary, the muscle may be coapted by a few sutures. The skin is very carefully closed by interrupted stitches of silk, silkworm-gut, or horse-hair. A dry gauze dressing and bandages complete the dressing. The drain is ordinarily removed within forty-eight hours. If decompression on one side is ineffective or insufficient, the same procedure may be repeated on the opposite side at the same sitting or later. The patient is subsequently kept off the back as far as possible to prevent hypostatic complications.

This operation is not for universal use and at present it is not practised as much as formerly, because we now know that many of these patients practically decompress themselves by hemorrhage from the nose, ear, throat, and sometimes through a compound fracture of the vault or multiple cracks therein.

Lumbar Puncture.—This is another means of reducing intracranial tension, but it has a limited value and is dangerous in unselected cases, because sudden relief of pressure in the skull often allows the brain to drop down upon the rim of the foramen magnum, actually corking or plugging the latter so promptly and effectually that death is instantaneous from mechanical pressure upon the vital medullary centers. I have seen such a case in which death was sudden, and at autopsy the ridge in the brain made by the edge of the foramen magnum was readily visible.

Lumbar puncture (or *spinal puncture* or *spinal tap*) is performed by locating the top of the fourth lumbar vertebra which is on the level of the highest part of the crest of the ilium. The hollow needle is introduced in the interspace between the second and third, or the third and fourth lumbar vertebræ about 1 inch lateral to the spinous process. The skin is first painted with tincture of iodin and the patient lies on the side or is supported in a sitting position. The styleted needle is at least 4 inches long and has a caliber as large as the lead of a pencil. It is directed toward the median line of the spine and slightly upward, and penetrates a variable distance, depending upon the musculature, until a decided change of resistance is felt. This usually means that the subarachnoid space has been entered and spinal fluid under tension will then escape. It should be allowed to flow out slowly, and meanwhile careful watch is kept on the pulse and respiration to guard against the too sudden release of fluid. If any obstacle is encountered during the introduction of the needle, it is to be wholly or partly with-

drawn and re-introduced. If blood escapes at first, it is quite likely that a vessel has been penetrated en route; if, however, it is mixed with the cerebrospinal fluid rather uniformly, we then have valuable evidence of basal hemorrhage, constituting the so-called "bloody tap."

Venesection is another method of reducing intracranial tension, but it is applicable only in the second or early third stage of compression, and for that reason has limited value. It is far less useful in traumatic than apoplectic cases and should not be employed unless the pulse is full and bounding. The blood is best extracted from a vein at the bend of the elbow, and an amount is withdrawn sufficient to measurably reduce the volume of the pulse. I have never known this method to be used in any traumatic case.

Cerebral Localization and Topography

As a result of much experimental research and careful clinical observation, numerous sections of the brain have been mapped out, and the function of these various areas is now known with such a degree of accuracy that knowledge of them is very important in interpreting symptoms of head injury.

From a clinical and practical standpoint it will be recalled that the *brain substance* is divided into an outer or superficial portion made up of *gray matter* called the *cortical portion* or *cortex;* and of an inner or central or deep portion made up of *white matter* known as the *medullary portion.*

The *cerebrum* is all that main portion of the brain occupying chiefly the vertex of the skull, and the *cerebellum* is that under, smaller portion, lying in the posterior fossa of the base of the skull. The *pons varolii* is the bridge that joins the cerebellum to the medulla, the latter being a bundle of fibers between the pons and the *spinal cord.*

The *cerebrum* is divided into two hemispheres by the sagittal suture, and each half of the cortex thus formed has numerous fissures (or sulci) and convolutions (or gyri) as indicated in Fig. 444. Of these, the three fissures of greatest surgical importance are the *fissure of Rolando*, the *fissure of Sylvius*, and the *parieto-occipital fissure.*

Rolando's fissure, or the *Rolandic area*, is located on the skull by marking the distance from the root of the nose (nasion) to the occipital protuberance (inion). On this line locate a point a little back of half the distance (0.557 accurately) and this will denote the upper end of the fissure. From this point drop an angle of 67 degrees downward and forward for $3\frac{1}{2}$ inches, and this will outline the entire extent of the

fissure. This angulation is readily obtained in practice by folding a square of cardboard or thin metal in half, thus forming a right-angled triangle. If now the right angle is bisected, an angle of 45 degrees is formed, and if this is bisected an angle of 67.5 per cent. is produced, and the pattern thereof can be used as a guide by placing the summit of the triangle at a point midway between the nasion and occipital protuberance (Chiene method) (Fig. 444).

Fissure of Sylvius is located by (1) determining "Reid's base line," which runs from the lower margin of the orbit to the upper border of the external auditory meatus.

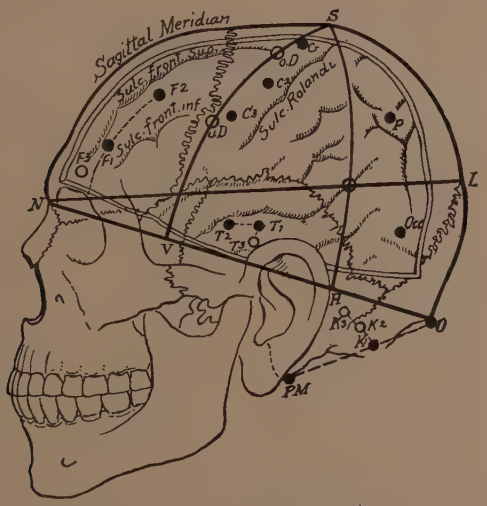


Fig. 444.—Craniometry with points for trephining (indicated o) to reach various lesions (indicated •).

(2) Draw another line parallel to the above, from the external angular process of the frontal (upper border of orbit) backward $1\frac{1}{4}$ inches. This is point "one."

(3) Locate the most prominent part of the parietal eminence and draw downward from it a line perpendicular to the base line, and on this take a point $\frac{3}{4}$ inch below the eminence. This is point "two."

A line (averaging 4 inches) joining points "one" and "two" will delimit the Sylvian fissure, and the anterior limb of it will be 2 inches behind the external angular process.

Parieto-occipital fissure is found by continuing the above line outlining the fissure of Sylvius to the median line, and where they meet this fissure will be found. It is also defined as opposite or a little above the Lambda; or $6\frac{1}{2}$ cm. above the inion (Thave); or seven-

eighths of the distance from the mid-sagittal point to the inion (Anderson and Makins).

The **convolutions** or **gyri** with their respective functions are indicated in Figs. 445, 446, 447. There is so much confusion in the nomenclature of these convolutions that synonymous terms are here given in brackets:

First frontal Superior frontal Gyrus frontalis superior	=	Second frontal Middle frontal Gyrus frontalis medius.
Third frontal Inferior frontal Gyrus frontalis inferior	=	Quadrate lobule Precuneus.
Fusiform lobe Lateral occipitotemporal lobe	=	Lingual lobe Median occipitotemporal lobe.
Anterior central Precentral Ascending frontal Gyrus centralis anterior	=	Posterior central Postcentral Ascending parietal Gyrus centralis posterior.
First occipital Superior occipital	=	Second occipital Middle occipital.
Third occipital	=	Inferior occipital.

Likewise there is a good deal of confusion of terms denoting the fissures or sulci, and the following bracketed names are used synonymously:

Fissure of Rolando Central fissure Fissura centralis	=	Interparietal fissure Parietal fissure.
Second temporal fissure Middle temporal fissure	=	Postcentral fissure Sulcus retrocentralis.
First temporal fissure	=	Parallel fissure.

Functionating Cortical Areas.[1]—From a surgical standpoint the region about the Rolandic area is most important, as it is now believed that the fissure of Rolando (central fissure) divides the cortex of the brain into an *anterior* or *motor* and a *posterior* or *sensory* field. Sometimes this section is called the *sensorimotor cortical area.*

In this regional division of function there is resemblance to the spinal cord (Figs. 445–447).

Motor Area, or the Motor Cortex.—This lies along a narrow strip about 1 cm. wide situated in the anterior central convolution (ascending frontal), reaching to the depth of the fissure of Rolando. The upper limit overlaps on the midline of the hemisphere (the paracentral

[1] Cushing's article in Keen's *Surgery* is largely used.

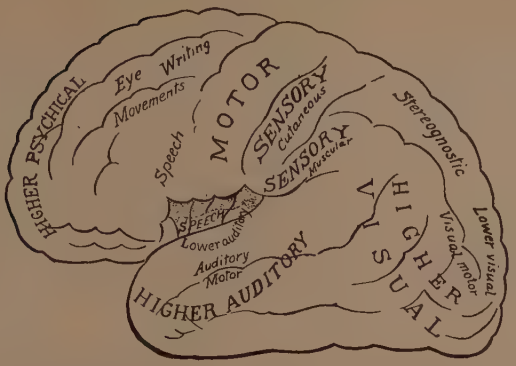


Fig. 445.—Cortical centers of the brain for the higher faculties.

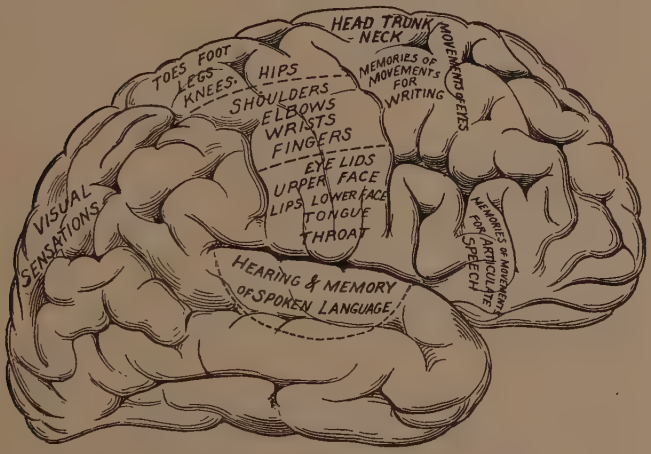

HEAD TRUNK NECK
MOVEMENTS OF EYES
MEMORIES OF MOVEMENTS FOR WRITING
TOES FOOT LEGS KNEES HIPS
SHOULDERS ELBOWS WRISTS FINGERS
EYE LIDS UPPER FACE LIPS LOWER FACE TONGUE THROAT
MEMORIES OF MOVEMENTS FOR ARTICULATE SPEECH
VISUAL SENSATIONS
HEARING & MEMORY OF SPOKEN LANGUAGE

Fig. 446.—Cortical centers of the brain (right half).

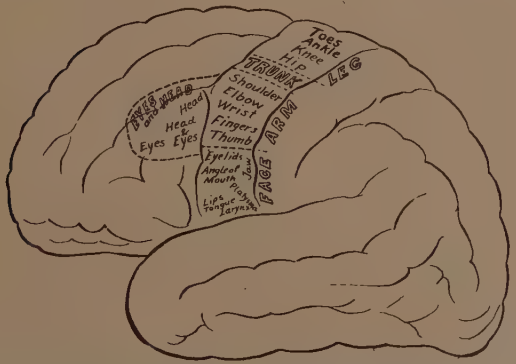


Fig. 447.—Motor-sensory cortical portion of the brain and its locational centers.

lobule), and the lower limit does not extend as far as the fissure of Sylvius. Cushing states that the Rolandic fissure is not straight, but

is broken by two and sometimes three angles (genua) of surgical importance. Above the *upper angle* (superior genua) is a small triangular area which, when stimulated, produces movements of the hip, knee, and toe. Opposite to this lie centers for movements of the chest and abdomen. Between it and the *middle angle* (*genu*) are the centers for the upper extremity, the shoulder being higher than the hand and fingers. Opposite this middle angle (genu) are centers for the neck, and below it those for the face and eyelids above and lips below. Still lower and generally below an *inferior angle* (*genu*) are centers for the jaws, tongue, vocal cord, pharynx, etc.

In other words, the upper third of this region has to do with motor control of the lower extremity and chest and abdomen; the middle third, with the upper extremity; the lower third, with the face and head.

From this area the pathway of distribution is via the pyramidal tract, and this latter degenerates if the cortical area is sufficiently affected.

Adjacent to this motor area are certain other centers which on stimulation produce various complex acts, thus:

Pars Opercula.—This lies below the anterior central convolution (first frontal), and it controls sucking, chewing, sneezing, and vocalizing movements (it is near the vocal speech center of Broca).

Second Frontal Convolution (*Gyrus Frontalis Medius*).—Stimulation of this causes movements of the head and eyes to the opposite side.

Sensory Area.—This section for common sensation occupies a place in the posterior central convolution (ascending parietal) corresponding to that of the motor area in the anterior central convolution (ascending frontal). It lies largely in the cortex buried in the fissure, and occupies superficially only about one-half of the above-named convolution. Tactile and muscular sense and the capacity of discriminating points in contact lie close to this posterior central convolution (ascending parietal) (Fig. 448). Pain and temperature sense are probably in the intermediate postcentral zone of Campbell. The recognition of objects, notably the stereognostic sense, is located as far back as the parietal lobe (Walton and Paul).

The fibers to this sensory area pass from the optic thalamus in the "cortical lemniscus" (Mankow) of the corona radiata to the post-Rolandic territory, and in their course they lie in the posterior part of the internal capsule.

Visual Area.—The primary receiving station for *sight* impressions is the occipital lobe, particularly on its mesial surface in the calcarine

area. The investing field (visuopsychic) extends on the outer surface (of the left side) in the second occipital convolution as far as the angular gyrus, where also lies the visual word center (reading) which participates in speech mechanism. The lingual lobule below the calcarine fissure appears to be associated with color perception (Cushing).

Auditory Area.—Sensations of *sound* are primarily received in some portion of the superior temporal convolution, and they are "converted into conscious perceptions" in adjoining parts of the temporal lobe, those on the left side in particular being concerned with the auditory end of speech mechanism. "Extensive lesions on the right side may give rise to no appreciable impairment of hearing on the same side, and there is much confusion over the unilaterability or otherwise of the registration of auditory impulses" (Cushing).

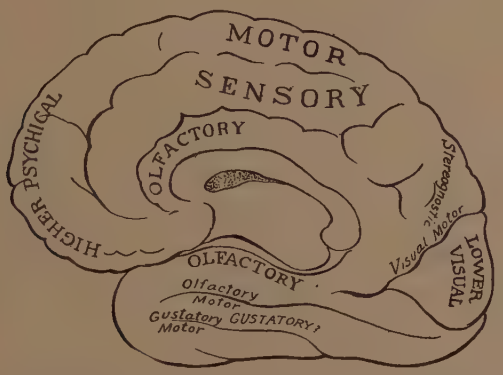


Fig. 448.—Cortical centers of the brain (left half).

The elaboration of the primary sound-producing stimuli into tone perception, word perception, etc., occurs in the district enveloping the primary receiving station; this is known as the auditopsychic area.

Olfactory Area.—The center for the sense of *smell* is chiefly in the pyriform lobe; there is some difference of opinion as to the part played by the adjoining areas of the uncinate gyrus, cornu ammonis, etc.

Gustatory Area.—The center for the sense of *taste* is not definitely determined, but is probably at the lip of the limbic lobe, near the uncus. The smell and taste centers are thus placed just to the outer side of the pituitary fossa and hence are relatively approachable surgically.

Speech Area.—In right-handed persons there are four speech centers on the left hemisphere:

(1) Recognition of *spoken words* is in the outskirts of the superior temporal convolution (*i. e.*, close to the primary auditory center).

(2) The center for *vocal* or *motor speech* is in the posterior end of the inferior frontal convolution (third frontal); this is "Broca's convolution."

(3) The *visual word center*, concerned in reading, is in the angular gyrus.

(4) The *writing center* (if such exists) is at the posterior end of the gyrus frontalis medius (second frontal).

It is not improbable that the fifth center exists in the parietal lobe, associating the sense of touch with speech mechanism. It is to be remembered that no part of this cortical speech mechanism can be damaged without to some extent affecting the rest; the most serious

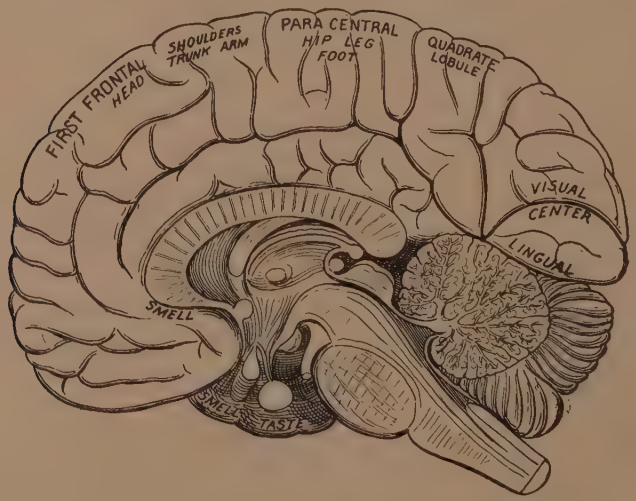


Fig. 449.—Sagittal section of the brain showing segmental sections.

disturbances arise from involvement of (1) and (2), these being known as the "primary couple" of Wylie.

Frontal lobes have apparently to do with the higher mental faculties (like reasoning, attention, and self-control), and lesions here, especially on the left side, are commonly attended by dulness, apathy, loss of concentration, and imperfect self-control.

Silent Areas or Association Fields.—This refers to those uncharted regions of the cerebral cortex (mainly on the right side) concerned in the complex processes of association, and lesions of these are "silent" or symptomless, so far as our present knowledge is concerned.

Basal Ganglia, Crura Cerebri, Corpora Quadrigemina, and Pons.—Injury to these is surgically inaccessible, and tumors, hydrocephalus, and apoplexy are the ordinary lesions (Fig. 449).

Caudate and Lenticular Nuclei and Internal Capsule.—Involvement may cause hemiplegia on the opposite side; if the *posterior* part of the capsule is involved there will be sensory changes, otherwise none exist.

Optic thalamus involvement may cause motor disturbances on the opposite side (contralateral), like choreiform movements, athetosis, or disturbances of sensation, and also hemianopsia in some cases (Fig. 450).

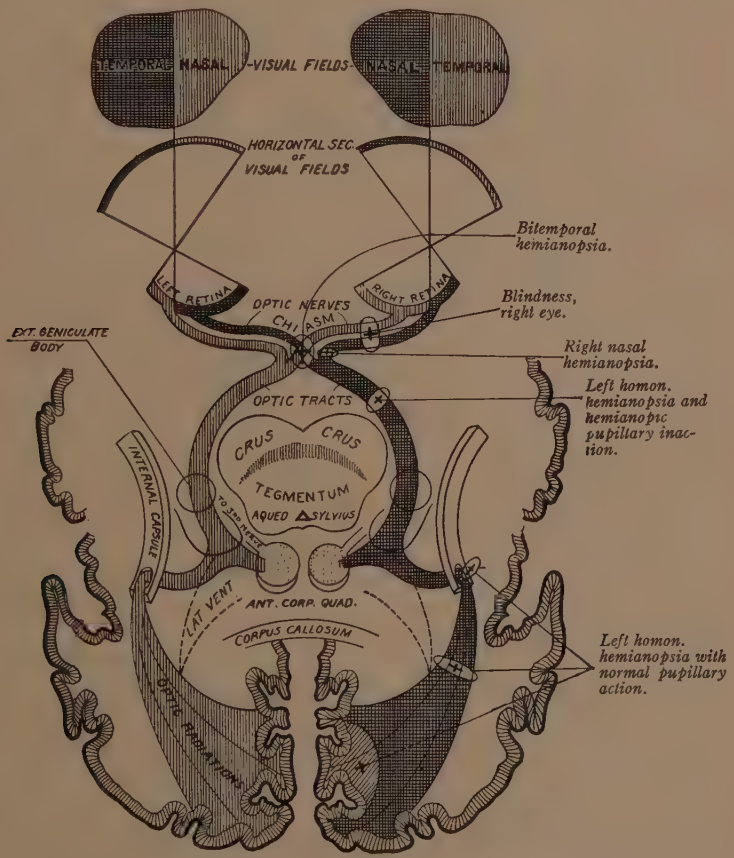


Fig. 450.—The optic tracts and visual fields; + marks indicate lesions causing hemianopsia.

Crura cerebri involvement may cause paralysis of the opposite limbs and of the motor oculi (third nerve) of the same side.

Corpora quadrigemina involvement may lead to ophthalmoplegia, to blindness, and deafness when the geniculate bodies are implicated, and to a reeling gait and vertigo and a tendency to fall backward.

Pons involvement shows variable signs; the most characteristic

is a combination of cerebral nerve paralysis on the same side (homolateral) as the lesion, with paralysis of the limbs on the opposite side; this is also known as "crossed hemiplegia." If the involvement is above the decussation, the paralyses will be homolateral.

Cerebellum involvement produces inco-ordination of gait and station, with a coarse ataxia accompanying volitional movement. If the *middle lobe* is involved, these symptoms are bilateral; if one *lateral lobe* is affected, the signs are homolateral. In walking, these patients are apt to reel toward the affected side, and in some cases convulsions occur (cerebellar fits). Nystagmus and other ocular signs may coexist, and spasticity and arching of the spine occur in irritative lesions. After lesions of one lateral lobe, symptoms may wholly disappear; and, indeed, a lateral lobe may be excised without causing loss of function.

Subcortical area (**white matter**) involvement causes symptoms identical with those of the corresponding portions of the cortex. In a schematic manner these foregoing lesions are graphically indicated in Fig. 450.

Intracranial Hemorrhage

As already stated (see pages 251, 252), there are several traumatic sources of origin for this within the cranium, either with or without fracture of the skull.

Depending upon the *location* of the bleeding we refer to four sites:

(1) *Extradural or Epidural Hemorrhage; Hematoma of Dura Mater; Meningeal Apoplexy.*—Hemorrhage between dura and bone.

(2) *Subdural or Intermeningeal.*—Hemorrhage between dura and arachnoid.

(3) *Subarachnoid.*—Hemorrhage between pia and cortex.

(4) *Intracerebral or Cerebral Hemorrhage, or Central Hemorrhage, or Cerebral Apoplexy.*—Hemorrhage in the substance of brain.

In order of *frequency*, bleeding may originate from: (*a*) Meningeal vessels; (2) pia-arachnoid vessels; (*c*) venous sinuses; (*d*) intracerebral vessels.

EXTRADURAL OR EPIDURAL HEMORRHAGE; HEMATOMA OF DURA MATER; MENINGEAL APOPLEXY

This is the commonest source of origin and is generally due to laceration of the middle meningeal artery, although the veins and venous sinuses occasionally are implicated. The blood ordinarily collects in the temporal region between the skull and untorn dura; but

if the latter is damaged, the bleeding may be extradural and subdural as well.

Anatomy.—The middle meningeal artery enters the cranium through the foramen spinosum and then runs in a groove on the temporal bone, and between the latter and the dura. It divides into an *anterior* branch passing forward, and a *posterior* branch passing backward (see Fig. 224). From its more vulnerable location, the anterior branch is much more commonly involved.

Extradural hemorrhage may far less frequently occur in the frontal and occipital regions.

Causes.—*Fractured Skull.*—Simple or compound, usually as cracks or fissures of the temporal vault, spreading more or less into the base. Penetrating wounds are another source.

Without Fractured Skull.—A rather rare source, generally arising from *contrecoup* and located on the side opposite to the receipt of violence, being associated with cerebral contusion.

Site, Shape, and Size of Clot.—Usually it is circumscribed and disk-like, and in one of the three sites indicated on page 252. The central part is generally thickest, the main source of pressure, and the means by which the dura is stripped from the bone.

The site, rate, and extent of the bleeding, and the cohesion of the dura, determine the *size* of the clot.

Dural adhesion is most marked in the young and the old, and hence this variety of hemorrhage is least likely at age extremes.

The average weight of clots is from 4 to 6 ounces; if larger than this, intracranial pressure usually is sufficient to cause death.

Symptoms.—The essential element is the extent of *compression*, as this is the determining factor in diagnosis as well as treatment. In all, the *history* of the case is exceedingly important, particularly that portion relating to the sequence of symptoms in an effort to ascertain if, after the primary concussion, there was a period of consciousness and apparent well being—the so-called "free interval." The preliminary *examination* is equally important, and when possible the entire scalp should be shaved, so that an otherwise hidden abrasion, hematoma, or area of ecchymosis may be brought into view. Careful, systematic bilateral palpation with the flat hand is very valuable as a means of determining irregularity or altered consistency in scalp and skull. Percussion should be made just as carefully as if the chest was being examined and in the same comparative manner.

Clinically speaking, there are four groups of cases, each dependent upon the nature of the injury, the site, the extent and rate of the

clotting, and to a lesser degree upon the individual (age, habits, general physique).

Group 1. Concussion, Free Interval, Compression.—This is the classical type of extradural hemorrhage, generally indicating middle meningeal involvement.

After an injury to the head the patient is rendered unconscious for a variable time (usually short), and then arouses or is aroused sufficiently to talk and recognize persons and surroundings. Walking may even be possible, and in some few cases return to work has occurred. During this "free interval" there is usually complaint of pain in the head, dizziness, nausea, roaring in the ears, and weakness; some few patients assert freedom from all subjective symptoms. This sort of patient, if seen by a physician, is usually regarded as suffering from concussion (with perhaps a scalp wound or hematoma) or an uncomplicated fracture of the skull. If the patient is drunk when hurt, treatment may be given for a scalp wound or some minor injury, and then sometimes the victim is returned to a police cell or put to bed, or perhaps allowed to go about unattended. Later, usually within a few hours, some twitching is noticed in moving the hand or forearm or face. Later still, this twitching may become convulsive, and go on to paralysis. The drunken patient may receive no further notice until stertorous respiration or deep coma attracts attention enough to call a physician, who discovers paralysis of an extremity or of one side of the face.

In other words, the *immediate* symptoms of onset are those of concussion with a succeeding "free interval."

The *intermediate* symptoms are irritative, as indicated by twitching, jerking, or actual clonic convulsive movements in the face or extremity (nearly always the upper).

The *late* symptoms are paralytic, in which the face or extremity is flaccid. In left-sided hemorrhage motor aphasia commonly occurs.

Unconsciousness may be absent, partial, or complete; it is always present with clots of large size, causing compression.

Sensation is generally absent in the paralyzed limbs. With *general compression* there are cardinal signs of the condition, such as *pupillary changes* (contracted or irregular at first, and later dilated and usually squinted toward the lesion); *choked disk; increased blood-pressure; slowing* and *deepening of respiration; slow pulse*. The pupillary signs may at first be limited to the affected side.

In a general way it may be stated that the *immediate* onset of compression signs indicates depressed fracture or massive hemorrhage; *intermediate* onset of compression (within a few hours) indicates hemor-

rhage; *late* onset of compression (after thirty-six or forty-eight hours) indicates infection or secondary bleeding, as from a vessel temporarily plugged by a clot, bony spicule, or foreign body.

Complete hemiplegia practically never occurs from cortical hemorrhage, because a clot large enough to invade the entire motor area invariably induces some general fatal compression.

For the same reason, meningeal hemorrhage rarely affects the lower extremity, because the leg center is so high on the cortex and thus is too distant from the site of initial rupture of the vessel.

Group 2. Concussion, No Free Interval, Compression.—Here the patient becomes unconscious and remains so, and there may or may not be local evidences of an irritative or paralytic form before compression becomes manifest.

This type follows extensive fractures (simple, compound, or depressed), leading from the vault to the base, or vica versa; it also occurs with contusion or laceration, and in gunshot and foreign body injuries.

A few of these patients are seen early enough to follow the transition from concussion to compression, and this is usually indicated by a spreading of irritative signs (twitching or convulsion) into paralysis and increasing compression.

Group 3. Compression Immediate.—These are generally fractures of the base of the skull associated with considerable comminution or depression of the vault, often compound. They occur also from gunshot or other penetrating wounds ordinarily involving the trunk of the middle meningeal, the pia-arachnoid, or sinus vessels separately or together, and thus they resemble subdural hemorrhage and contusion. The cardinal signs of generalized compression generally appear at once and most of the patients promptly die.

Group 4. No Concussion, Apparently Well, Compression.—This is a very rare group, in which there may be few objective evidences of injury, and yet in a few hours signs of compression appear. Some in this group may exhibit evidences of a comminuted or depressed fracture of the skull without other signs, and within a few hours a spicule of bone or a release from clotting may induce sudden massive bleeding and accompanying intracranial tension.

Treatment.—The main indication is to stop the bleeding, and thus prevent or relieve compression.

In case of doubt it is often safer to operate: but a reasonable time may elapse in stationary cases and when symptoms are subsiding.

To reach the meningeal vessels use the topographic zone already indicated (see pages 462, 463); a safe and reasonably accurate rule is

that of Vogt, who locates the main vessel by marking a point two fingerbreadths above the zygoma and a thumbbreadth behind the vertical process of the malar.

A bone-flap, convexity upward, may be turned down here (after the manner indicated on page 259), or the site may be reached through the subtemporal decompression incision of Cushing (see page 260).

If a depressed fracture is present, the area adjacent to it may be first trephined for elevation purposes, the button of bone being removed as near to the region of the meningeal vessel as possible. The original traumatic or operative opening is enlarged as far as necessary to secure the bleeding vessel. Organized clot is generally scooped or irrigated away, and the dura is unopened unless it fails to pulsate or gives evidence of harboring a subdural effusion. If opened, the incision is made in such a way as to be well within the rim of removed bone; a semicircular or **M**- or **W**-shaped incision is usually made, and it is loosely sutured, tension permitting, after the clot is removed.

Sharp spiculæ of bone are to be removed, but flattened segments of depressed skull can be left unless caved in enough to actually touch the dura. A wick of rubber tissue or a few strands of twisted catgut or silkworm-gut are introduced to the dura level, and brought out at the lower angle of the wound or through a special stab made in the flap. It is unwise to introduce drainage into the brain substance.

Bleeding points inaccessible to hemostasis by ligature or pressure may sometimes be controlled by wicks of gauze, and these are brought to the surface after the same manner as drainage; small pieces of muscle or fascia may also act as hemostatic patches. Drains or wicks are usually removed in twenty-four to forty-eight hours.

If the clot is not reached on the side expected, the surgeon is often justified in trephining on the opposite side.

Prognosis.—Cushing states that 80 per cent. of these cases end fatally if unoperated upon, 60 per cent. dying within the first day; 67 per cent. of the operated cases recovered.

The outcome is dependent very largely upon the degree of compression, as this is a greater determining factor than the apparent extent of the injury.

Compound fractures and certain fractures of the base with free bleeding apparently decompress themselves to some extent, and the same is true in some cases where there has beena loss of skull and brain substance. In simple fractures I have known of a number of cases in which the multiplicity of the cracks or fissures anatomically prevented compression.

SUBDURAL HEMORRHAGE

This form is commoner than the preceding, according to Cushing, but most observers rank it second in frequency. It occurs typically in spreading fractures of the base of the skull with diffuse venous hemorrhage. In other cases there may be foci of bleeding capable of producing localizing signs.

Symptoms.—The typical form presents a picture of coma with signs of compression more or less marked; in other words, the signs of "Group 3" of extradural hemorrhage are very closely paralleled. It is quite impossible to be certain as to the diagnosis in many instances, but in a general way the symptoms of progression are less rapid because the bleeding is nearly always venous rather than arterial. The temperature is likely to be higher, and irritative symptoms (like twitching or convulsions) and signs of pressure are likely to be unilateral. Generally speaking, a diagnosis of subdural hemorrhage can be entertained in any case of profound concussion plus compression. The diagnosis is rendered less conjectural if lumbar puncture discloses bloody fluid. Contusion of the brain with or without laceration may also coexist, and some added confusion may arise if *acute traumatic cerebral edema* is sufficiently present to produce signs of pressure. This last somewhat resembles the edema of delirium tremens and it must not be confounded with it.

Treatment.—The expectant plan may be followed unless compression is advancing, and then some method of decompression must be adopted. As stated, most of these cases are associated with basal fractures (usually middle fossa), and for that reason the *subtemporal decompression* method of Cushing (see page 260) is probably the most uniformly satisfactory, as it affords a good approach and reasonable subsequent protection in the event of a hernia of the brain. After the dura has been exposed and opened (in many cases it is already torn and brain substance oozes out) the temporal lobes can be elevated and bloody fluid or clots better removed. Drainage is usually needed; none should be employed unless a reasonable amount of fluid continues to flow out. If the brain should bulge, the split temporal muscle and scalp should be sutured as closely as possible notwithstanding.

Prognosis.—This largely is that of fractured base, and about 50 per cent. of the latter recover; with early decompression the proportion is perhaps slightly better.

SUBARACHNOID HEMORRHAGE

This variety occurs with contusion and laceration of the brain and relatively few cases are relievable because medullary compression is so great that death occurs promptly. If the bleeding occurs over the hemispheres and is reasonably localized, then signs of subdural hemorrhage usually exist.

Treatment.—Decompression and pricking of the membrane between the convolutions may benefit some localized cases with inconsiderable contusion or laceration. At operation the involved portion is of a characteristic cherry-red color. In some of the unoperated cases these arachnoid areas later organize and form thick-walled cysts, giving signs of tumor.

Sometimes ruptured aneurysms of superficial cerebral vessels produce hemorrhage of this type.

Prognosis.—This depends upon the associated injury. In the localized forms over the hemispheres the outlook is good; otherwise it is generally very unfavorable.

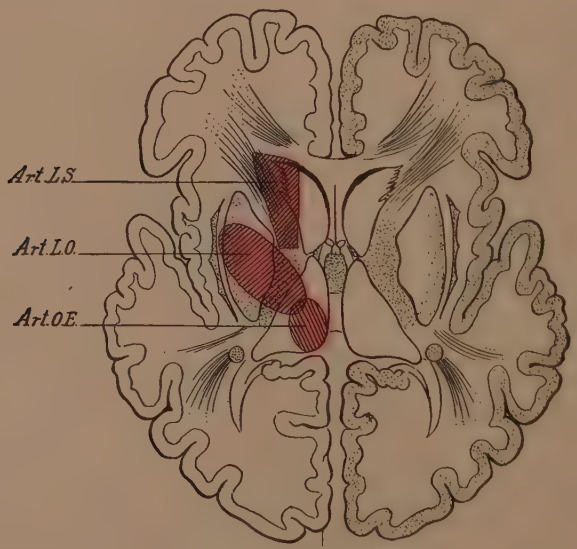


Fig. 451.—Areas usually involved in cerebral hemorrhage: *Art.L.S.*, Lenticulo striate, or "artery of apoplexy"; *Art.L.O.*, lenticular optic artery; *Art.O.E.*, external optic artery.

INTRACEREBRAL HEMORRHAGE (CEREBRAL APOPLEXY)

This never occurs as the result of external injury unless produced by a bullet, weapon, or some form of penetration of the skull, and such a rare occurrence would probably be immediately fatal because of the

damage inflicted on the intervening vessels and structures before those deeper in were reached.

This type of hemorrhage is ordinarily due to rupture of one of the vessels in the circle of Willis; the anterior branch of the middle cerebral ("Charcot's artery of apoplexy") is involved in 60 per cent. of such cases. Miliary aneurysms of these vessels, arteriosclerosis, heart and kidney disease, syphilis, tumors, and other non-traumatic causes are at fault in the average case (Fig. 451).

LATE TRAUMATIC APOPLEXY

This is the term recently given by Bollinger to certain cases of cerebral apoplexy occurring some days after head injury—the so-called "Spätapoplexie." Eisendrath, citing Stadelmann, states that the longest recorded intervening clear period between the head injury and the apoplexy is four weeks.

A connection between head injury and ordinary apoplexy is rarely sought to be established except in medicolegal cases, as in others the usual and ordinary causes are satisfactorily evident, and any more or less remote incident is usually regarded as coincidental. I have known 3 cases in which such claims were brought to court. One "stroke of apoplexy" occurred two days after the accident; another, seven weeks; another, one year.

From a surgical standpoint it is impossible for the needle-calibered "artery of apoplexy" to be broken by a blow on the head that fails also to break other vessels nearer the site of the violence; if this combination occurred, death would doubtless ensue. The most extensive forms of skull and brain injury at times may rupture many of the other vessels, yet those at the base escape, doubtless due to their splendid protection. The usual and ordinary cause of cerebral apoplexy is a diseased cardiovascular mechanism, and when the arterial pipe is ready to burst, it bursts independent of any injury or other extraneous element, although many so-called "exciting causes" may be regarded as productive and may, indeed, be coincidental. All sorts of physical and mental strain are thus denominated as "exciting causes," such as sneezing, running, coughing, turning quickly in bed, worry, grief, and many others; but these are merely *coincidental*, and not in the least *producing*, *actuating*, *determining*, or *ascribable causes*.

These every-day facts make it exceedingly difficult to place any reliance on the theoretic and unpathologic connection between a remote head injury and a subsequent cerebral apoplexy. Even in Germany, where this idea originated, there has been much disagree-

ment; and in this country, as stated, it is heard of practically only in medicolegal exigencies.

In some instances a fall incident to a "stroke" causes head injury, and some preliminary confusion may arise because of symptoms that are regarded as traumatic, but in reality are apoplectic; in other words, the previous history and the examination will determine that the apoplexy *preceded* and did not *succeed* the fall.

Complications and Sequelæ of Head Injury

These may be divided for description into (*a*) *inflammatory* and (*b*) *non-inflammatory*.

(*a*) *Inflammatory*.—Infection of the meninges: Epidural abscess; purulent pachymeningitis; subdural abscess; purulent leptomeningitis. Infection of the brain: Encephalitis; cerebral abscess. Infection of the sinuses: Encephalitis; cerebral abscess.

(*b*) *Non-inflammatory*.—Structural: Cranial defects (holes, depressions); hernia cerebri. Nervous: Paralysis (limbs, special senses, cranial nerves); epilepsy; insanity and the psychoses; hysteroneurasthenia.

Inflammatory Sequelæ

Infection of the Meninges; Septic Meningitis; Epidural Abscess; Purulent Pachymeningitis; Pachymeningitis Externa.—Ordinarily this is due to infected compound depressed fractures of the vault, and occasionally from infected wounds, hematomata, burns of the scalp, or superficial penetrations of the skull.

Symptoms.—In general, there are evidences of an infected scalp wound, with such signs as fever, chills, headache, vomiting, local tenderness, and percussion dulness. If the involvement is large enough and properly placed, there may be added signs of focal irritation or pressure.

Ordinarily these septic symptoms do not appear within the first three days, and in some exceptional cases they are delayed for several weeks, but in such cases the interval is occupied by symptoms of cortical or other irritation.

Infection may also enter from the frontal, ethmoidal and sphenoidal sinuses, and from the middle ear.

Treatment.—The focus having been located, the indication is to evacuate the pus through a suitable opening in the skull, care being taken to prevent damage to the parts about the abscess. When pus is diffused, multiple trephine opening may be necessary. The general treatment is appropriate to the existing symptoms of sepsis.

Subdural Abscess; Purulent Leptomeningitis; Leptomeningitis Interna.—This is the condition known also as *meningo-encephalitis* (Koenig) and *traumatic meningitis* (von Bergmann). The causes are the same as in the foregoing, but ordinarily a fracture of the base exists and the infection travels through a ruptured ear-drum or broken ethmoid or orbital plate of the frontal.

The typical signs may not appear until evidences of the initial concussion or injury have passed, and then gradually or suddenly a *stage of irritation* commences, with increased temperature and pulse, headache, nausea, vomiting, chills. If the purulent collection is over the vertex, there may be focal signs; if at the base, there will be rigidity and tenderness of the muscles of the neck and involvement of some of the cranial nerves, indicated generally by such signs as pupillary contraction, squint, facial spasm or asymmetry. Soon follows the *stage of paralysis*, and then the evidences of generalized compression appear (choked disk, respiratory involvement, and slow pulse). Kernig's sign (impossible to straighten the bent knee without lifting the pelvis) is present and there is a tache cérébrale. Lumbar puncture obtains pus (usually showing staphylococci or streptococci) and a leukocytosis is present.

Treatment.—Trephining may be effective in some cases of localized purulent effusion; but in others with a generalized collection of pus little can be expected even from multiple openings for decompression. Autogenous and heterogenous vaccines are sometimes beneficial.

Prognosis.—Cases that recover may give permanent evidences of muscular paralysis or contracture. The involvement of the cranial nerves (especially the facial) is often recovered from. Hearing and sight impairments are often benefited and sometimes entirely relieved.

Generally speaking, the outlook is poor as to life and ultimate function.

Infection of the Brain.—Encephalitis.—Inflammation of the substance of the brain is due to infected penetrating wounds or compound depressed fractures; very rarely it may follow infection from one of the sinuses or canals. The condition resembles subdural abscess (meningo-encephalitis) from a clinical standpoint and practically cannot be differentiated from it.

Cerebral Abscess; Abscess of the Brain; Acute Suppurative Encephalitis.—The cerebrum is involved twice as often as the cerebellum, and the temporal region is the usual site.

Frontal lobe involvement is very rare despite the contiguity of the frontal sinus and the frequency of fracture of this bone.

Abscesses may be solitary or multiple, and when due to trauma they are *contiguous to the seat of origin* (McEwen, cited by Eisendrath), and in this respect they differ from abscesses due to other causes. Recent abscesses contain a reddish pus in a more or less well-defined cavity; later, the pus is green and odorous. Staphylococci and streptococci are usually found in those of traumatic origin; others may show pneumococci and typhoid or colon bacilli.

Causes.—Infected fractures of the vault or penetrating wounds of the skull are the usual traumatic sources. About 15 per cent. of cases are said to be traumatic, and other sources of origin are otitis media, sinus involvement, and metastases from pus foci elsewhere. Middle-ear disease is probably the commonest of all sources and cerebral abscess may result from it years after the process has become chronic; cases are recorded following otitis media that existed nearly half a century.

It is very questionable if an abscess can occur from head injury in the absence of a fractured skull. If such an origin is to be regarded as causative, a preceding hemorrhage, contusion, or laceration must have existed, and no other more usual source of origin (as the middle ear) is known to exist.

Symptoms.—There are two clinical forms, the *acute* and *chronic*.

Acute forms ordinarily do not appear within a week of the accident, and the *initial* stage begins with headache, nausea, fever, and chilly sensations. Mental torpor or restlessness may exist. There may be local tenderness in the neighborhood of the original wound or fracture.

A *latent* stage may then appear, lasting several days, with apparent subsidence of the preceding symptoms. The *manifest* stage then appears, in which all the foregoing symptoms are exaggerated and the mental condition is one of irritation or apathy. If the purulent collection is so situated that local pressure is possible there will be focal manifestations (as facial paralysis or pupillary changes). Leukocytosis is present.

The *terminal* stage is that of compression often with pyemic evidences.

Chronic forms may develop a long time after the initial injury, and in some reported cases years have elapsed. As stated previously, there is always a direct pathway from the original injury to the abscess in such instances.

The *symptoms* of this form are practically those of tumor, and no evidence of trouble may exist unless the pus collection is large enough or so situated as to cause pressure on some focalizing zone. Many

abscesses are discovered postmortem in so-called "silent areas" which in life gave no symptoms whatever; occasionally rather large abscesses are thus found in regions that apparently should have produced focal symptoms. Sometimes an encapsulated or quiescent chronic abscess undergoes changes in size or location, and then symptoms like those of acute abscess appear. Some cases are subject to periodic exacerbations of this sort characterized by symptoms appropriate to their location.

Some of these patients are often regarded as epileptics (abscess in region of motor cortex), insane (abscess in frontal region), or suffering from tumors or cysts (cerebral or cerebellar), and the exact conditions are often not determined until autopsy.

Differentiation in the *acute forms* is to be made from meningitis (especially purulent leptomeningitis), encephalitis, and sinus thrombosis.

The first two of these are difficult to differentiate; but in the last, the typical rise and fall of temperature, the chills, and the usual middle ear or mastoid involvement, or jugular tenderness usually serve as distinguishing factors. A careful history is of prime importance and probably offers the best clue to the nature and extent of the condition.

Meningitis may sometimes be determined by examination of the fluid obtained by lumbar puncture; with abscess the leukocytes are not increased, but in meningitis (even of the tubercular variety) a leukocytosis pertains. Normally there are but one or two leukocytes in a 5-c.c. centrifuged specimen of cerebrospinal fluid; in ordinary meningitis there may be 100, and in tuberculous meningitis 952 (Cushing, quoting Fuchs and Rosenthal).

Lumbar puncture must be carefully performed if compression exists, as the release of pressure may crowd the brain-stem into the foramen magnum and produce instant death. For this reason only a small amount of fluid should be aspirated.

Abscess pus may be sterile, especially in chronic forms.

x-Ray examination is sometimes helpful.

Treatment.—The primary antiseptic care of scalp wounds and compound fractures has done much to diminish abscess formation, and the importance of this sort of prophylaxis cannot be overestimated.

Next in importance is early recognition and the institution of exploration and drainage before the later stages of the process are reached.

Operation in traumntic cases is generally performed over the site of the initial injury, and the trephine opening is so planned that it

affords the maximum exposure for drainage. When possible, access can be readily obtained by the method described as subtemporal decompression. If the abscess is not apparent on exposure of the cortex, a thin knife or hollow needle is inserted into suspected territory, and when the focus is thus reached, a channel of exit is provided and gauze or other drainage introduced. Irrigation is unwise unless the abscess cavity is well defined. The gauze is usually undisturbed for several days, and the patient's head is placed in a dependent position to aid the escape of the pus.

In otitic cases, and others in the petrous region, operation is primarily of the mastoid type, with such added exploration as may be required.

Prognosis.—At best this is serious; but if the abscess is relatively superficial and attacked early, the outlook is better. The general mortality in operated cases is about 50 per cent.; those unoperated upon generally end fatally.

Sinus Thrombosis.—This is relatively rare and is commonest over the longitudinal sinus following infected wounds and penetrating fractures.

As a sequel of erysipelas and infections about the face, nose, and ear it is not uncommon, but most cases are related to mastoid infections or operations.

Symptoms.—These are (*a*) local to the sinus involved and (*b*) general or systemic.

(*a*) *Local Signs.—Longitudinal Sinus.*—(1) Signs of injury in the vicinity. (2) Tenderness or pain on pressure; nose-bleed is common. (3) If the channel is completely blocked, there will be evidences of general intracranial venous stasis.

Cavernous Sinus.—(1) Signs of injury generally in region of orbit or brow. (2) Exophthalmos (one or both eyes) and edema of the lids are the most typical evidences. (3) Choked disk, retinal hemorrhage, and congestion of the external orbital veins. (4) Supra-orbital pain. (5) Paralysis of the oculomotor nerves (third, fourth, and sixth).

Sigmoid Sinus.—(1) Signs of injury in the vicinity. (2) Tenderness along the dilated jugular. (3) Mastoid tenderness and edema. (4) Involvement of the ninth, tenth, eleventh, and twelfth nerves, ordinarily shown by dyspnea, hoarseness, and slow pulse.

(*b*) *General or Systemic Signs.*—In some cases these are the only evidences, and a diagnosis of typhoid, pneumonia, septic endocarditis, or malaria is often made.

The *temperature* is of the septic type (100°–105° F.). *Chills* and

sweats with increased pulse (100–140). *Nausea* and *vomiting*. *Pain in head* is severe, and it may be localized to the scene of trouble or wholly occipital. *Leukocytosis* always exists. *Pyemic* evidences, notably in the subcutaneous parts, joints, spleen, and lungs; sometimes pyopneumothorax or empyema may appear. *Mentally* the patient is usually alert and the mind is unaffected until late.

In every case the auditory canal must be excluded as a source of origin.

Treatment.—In the *longitudinal sinus* exposure and removal of the clots is indicated.

In the *sigmoid sinus* a radical mastoid operation is performed and the sinus bared and opened. If the dura is invaded (meningitis or abscess) it is to be opened and drained. If the jugular is involved, it is ligated deep down in the neck, opened, and irrigated to wash out the clot to the open sinus in the mastoid region (Zanfel's procedure).

In the *cavernous sinus* little can be done; but enucleation of the eyeball and drainage from the sphenoidal fissure has been recommended. Subdural approach by the temporal route is anatomically possible, but surgically extremely hazardous.

Autogenous or heterogenous vaccines occasionally appear beneficial in all forms. The general treatment is for sepsis.

Prognosis.—Early operation is effective often in the longitudinal and sigmoid types of phlebitis, but it is nearly hopeless in the cavernous forms.

If pyemia, septic meningitis, or abscess occurs, the outlook is graver; but even then some of these cases recover if the general physique is capable of combating the infection.

NON-INFLAMMATORY SEQUELÆ

Cranial Defects.—These may occur as *osseous depressions* following fracture, or indentations without fracture, as from blows, falls, or missiles. These deformations are sometimes important in the frontal or bald areas from a cosmetic standpoint, but they rarely assume a dangerous significance unless the amount of depression is considerable. Stimson is authority for the statement that the brain can safely withstand an indentation amounting to 2 cubic inches. In some areas a very considerable depression would cause no effects whatever because the underlying brain is relatively distant from the skull, or because the contiguous brain region is "silent." In the Rolandic region the indentation is likely to be of greatest consequence as a possible inducing

cause of focal epilepsy; but even in this locality considerable inflexion is not necessarily a source of symptoms.

As previously stated, a diagnosis of pressure from a fracture of the internal table alone, without fracture of the external table of the skull, is so rare as to be negligible, and suspected cases have rarely been proved at operation or autopsy. Sharp edges or spikes of depressed fragments are generally smoothed off, and the underlying brain appears to acquire a remarkable tolerance for these and other irregularities.

Holes in the skull from the original injury (comminuted fracture, bullets, or missiles) or from operation are very common. In children the anterior fontanels usually remain open until about the second year. Some operations designedly provide apertures in the cranium. In certain locations visible pulsation of the brain remains, but after a time this usually lessens and often wholly disappears, even after the removal of a large "bone-flap."

The custom of covering such an opening by a plate of metal (aluminum, silver, gold, or platinum), celluloid, or rubber is now comparatively obsolete, as experience has shown that a thick fibrous or cartilaginous covering spontaneously forms, and that adhesions are less likely to attach to it than to a foreign substance introduced with the idea of preventing just such an occurrence. The irregular edges about these openings are promptly smoothed away, and in many of them a gristle-like formation completely occludes even a large opening within a few years. A case is reported in which an opening of about 2 inches square of the frontal bone was filled by osseous material after a lapse of twenty-five years (Stimson). Frost reports a case (cited and pictured by Cushing) of an extensive traumatic laceration with sloughing of a large part of the right hemisphere resulting in a cranial defect 5 by 6 inches.

The main factor is the condition of the dura, and if there are adhesions to it, the cranial defect is advantageous, in that expansion is permissible at each brain pulsation.

With an intact dura "the loss of bone should have no more effect on the brain than has the fontanel of the infant's skull" (Cushing).

If a hole is to be closed, a shell of bone can be taken from the patient's rib or tibia and implanted, or a section of scalp, and the attached periosteum and outer table may be slid over the defect (autoplastic method of Miller and Konig), and the place supplying the flap can be allowed to granulate or is skin-grafted.

Hernia Cerebri.—This occasionally occurs in compound fractures

or with loss of bone following decompression, and it is always an indication of intracranial tension.

Normally the brain, like the lung tissue, recedes when the dura is opened, and the extent and location of the cerebral prolapse obviously depends upon the nature of the injury, but in traumatic cases it rarely becomes as marked as in tumors.

The herniated brain may occasionally take on a fungoid growth (*fungus cerebri*), and this very rapidly recurs after it is excised. If the compression subsides or is relieved, the prolapse ordinarily recedes. In infected cases the danger of extension to the adjacent herniated brain is much increased, and such cases usually end fatally after a period of sloughing and necrosis.

Treatment.—This should be directed toward relieving the compression and preventing infection of the visible brain during the period of active prolapse.

Traumatic brain hernia usually spontaneously subsides when the internal pressure is relieved, and then the opening in the skull and scalp is suitably cared for.

SEQUELÆ OF NERVOUS ORIGIN

Paralyses

These are comparatively rare, and when they affect the limbs the involvement is usually partial, and the sensory and trophic changes coexist equally with those of motion. The usual combination is for a foot and a leg, or a hand and forearm of one side to become partly incapable of functionating, sensation being impaired over the same region. Atrophy, flexure contracture, and spasticity are usually later manifestations.

Much can be done to prevent deformities by guarding against contracture by suitable dressings and apparatus.

When present, considerable improvement attends the use of massage, vibration, electricity, baking, gymnastics, and forced usage. Tendon and nerve re-implantation are operative measures capable of bringing relief in selected cases.

Special Senses

Hearing and *sight* are most commonly involved, chiefly in connection with hemorrhage or infection incident to basal fractures. Recovery to some extent is quite probable in most cases, especially in the absence of infection.

Many of these patients show no structural aural or ocular defects, and in these the outlook is excellent, and ordinarily marked improvement can be promised.

Cranial Nerves

In examining these, the best and quickest method of determining the involvement of the usual grouping of them is to ask the patient to shut and then open the eyes and at the same time to snap the teeth forcibly; in this way the ocular and facial innervation will be promptly indicated.

The *seventh*, *sixth*, *third*, and *fourth* are most commonly involved in the order named.

First, or Olfactory.—Ordinarily involvement is due to hemorrhage, infection, or fracture of the anterior fossa (cribriform plate) in basal fractures.

Signs.—Loss or diminution of smell (anosmia) and diminution of taste on the side of the injury.

Differentiation.—Nasal catarrh, hysteria, involvement of the fifth nerve.

Prognosis.—Recovery usually is complete, although it may be quite slow.

Second, or Optic.—Involvement occurs under the same conditions as the preceding, and also with compression associated with choked disk or retinal hemorrhages.

Signs.—Partial or complete blindness on the side of the injury (amaurosis).

Differentiation.—Preceding eye defects and constitutional sources of atrophy or visual impairment.

Prognosis.—Good unless atrophy exists; recovery is the rule when due to involvement of the dural sheath alone.

Third, or Motor Oculi (Oculomotor).—Third in order of frequency, and generally it occurs from involvement of the anterior fossa due to hemorrhage or infection from basal fracture or orbital wounds.

Signs.—Ptosis, dilated pupil, and loss of reflexes for light and distance, with external and slightly downward tilting of eyeball.

Differentiation.—Constitutional or toxic preceding causes, such as syphilis, rheumatism, tobacco, alcohol.

Prognosis.—Good except when due to infection.

Fourth, or Patheticus (Trochlear).—Practically always involved in connection with the preceding and from the same sources.

Signs.—Double vision (diplopia).

Differentiation and Prognosis.—Same as above.

Fifth, or Trigeminus.—This motor-sensory nerve is rarely affected alone.

Signs.—The motor involvement prevents keeping the jaws shut (pterygoid and masseter), the sensation over the involved half of face is diminished or absent, together with a similar impairment of the conjunctival, nasal, lingual, and buccal membranes. A trophic ophthalmitis with corneal ulcers may also occur sometimes.

Differentiation.—Tumors and syphilis.

Prognosis.—Good except when infection is responsible.

Sixth, or Abducens.—Second in order of frequency, but usually involved with the other nerves controlling the eye (as the third and fourth).

Signs.—Internal squint (strabismus).

Differentiation and Diagnosis.—Like that of the third and fourth nerves.

Seventh, or Facial.—More commonly affected than any other, ordinarily from involvement of the petrous portion of the middle fossa; the eighth nerve is generally affected at the same time.

The facial supplies all the muscles of the face except those of mastication (innervated by the motor branch of the fifth) and also the stapedius, stylohyoid, buccinator, and platysma.

Signs.—The involved half of the face is smooth and drawn to the opposite side on attempting to grimace or laugh, the corner of the mouth drooping. The eye will not close, tears collect, the eyeball rolls upward and half the forehead cannot be wrinkled, and the affected cheek cannot be inflated. The tongue deviates to the sound side. Hearing is nearly always coincidently affected. Ordinarily the involvement is on the same side as a hemiplegia; if unassociated with a hemiplegia, it is due to involvement of the cortical facial center.

Crossed paralysis, with facial palsy on one side (that of the lesion) and of the limbs on the opposite side, is indicative of injury in the lower part of the pons.

Differentiation.—"Bell's palsy" due to rheumatism or exposure; peripheral involvement from neuritis, tabes or hysteria; otitis media.

Prognosis.—Good, as the majority recover.

Eighth, or Auditory (Acousticus).—Very frequently involved, and ordinarily it is accompanied by flaccid paralysis and is due to the same cause.

For methods of examination, see page 711.

Signs.—Deafness may be partial or complete to bone conduction and higher tone sounds.

In ordinary or catarrhal deafness hearing is deficient as to *aërial conduction*, but normal or nearly so to *bone conduction*. If aërial and bone condition are both involved, the nerve or its connections are affected.

Differentiation.—Otitis media, nasopharyngeal, toxic, and other inflammatory causes.

Prognosis.—Generally good.

Ninth, or Glossopharyngeal; Tenth, or Pneumogastric; Eleventh, or Spinal Accessory; Twelfth, or Hypoglossal.—Very rarely involved; but if so, they are coincidently affected.

Signs.—Disturbances of speech, swallowing, and taste, with anesthesia of one-half the pharynx and larynx.

Trophic disturbances at the root of the tongue also occur when the ninth is affected.

Spinal accessory affection causes inability to raise the arm because the trapezius is innervated from it.

Epilepsy

No satisfactory estimate has ever been made of the number of cases of this disease due to head injury. This is mainly because it is so easy to obtain a history of head injury and so difficult to connect even marked operative findings in such cases with the seizures. Likewise in the vast majority of patients with marked cranial and brain damage no epilepsy occurs, although the extent and site of the injury are such as to theoretically make seizures almost inevitable.

At the present time epilepsy is regarded more as a symptom than a distinct entity, and injury is not now generally suspected of being so potent an originating factor, the best opinion holding that "there is something back of the lesion itself, some circulatory change, some disturbance with the cerebrospinal fluid circulation, as Kocher believed, or some autotoxic agent of metabolic origin, which is the torch to set off the discharge, cannot be doubted. Cholin in abnormal quantity has been found in the cerebrospinal fluid of epileptics at the time of the attack and is thought by some to be the exciting agent" (Cushing).

Personally, I believe it to be a very rare sequence of head injury because the number of cases subsequently seeking surgical relief for fits is exceedingly small considering the enormous number of head

injuries treated by surgeons in hospitals and private practice. For example, in my fracture statistics there were 276 cases of fractured skull, and of that large number it is reasonable to suppose that a certain proportion would return for treatment of developing complications. Compilation of thousands of cases treated in various local hospitals for all sorts of medical and surgical conditions would show exceedingly few cases of traumatic epilepsy.

With a very close personal knowledge of the recorded surgical findings in nearly 50,000 cases of railroad injury (some of these personally examined), I can recall very few instances in which claims have been made for damages on account of this complication, and it is reasonable to suppose that this type of allegation would be exceedingly frequent if traumatic epilepsy was a usual or ordinary complication of head injury.

Traumatic epilepsy (so-called) is supposedly due to irritation of the cortical areas of the brain (notably in the motor cortical region), and in this respect it differs from *idiopathic* or *essential epilepsy*, which is of unknown origin; and also from that group known as *reflex epilepsy* due to more or less distant irritative foci, such as nasopharyngeal inflammation, notably polypi and adenoids; auditory irritation; gastro-intestinal conditions; adherent prepuce; neuritis; painful scars and stumps; hysteria; menstrual, menopause and pelvic disturbances, and a variety of other extracranial sources.

The injuries most commonly looked upon as causative are those affecting the Rolandic area to such an extent that it is more or less constantly subjected to pressure or irritation by bone, foreign bodies, adhesions, new growths (tumors, cysts), or scar tissue.

Bony sources are generally compound depressed fractures in the temporal region; fractures of the base are very exceptionally causative from complicating spreading fracture, hemorrhage, or infection.

Foreign body sources are usually bullets and unremoved portions of hair, fabric, glass, wood, or metal.

Adhesion sources relate to dural attachments to the cortex, bone, or scalp, ordinarily associated with depressed, adherent, tender scars following infected or granulating wounds. Occasionally pia-arachnoid adhesions coexist or occur independently from meningitis or encephalitis. This is probably the most potent factor of all, and in many of this origin, external pressure over the involved area is capable of inducing an aura or convulsion (epileptogenic zones).

New growth sources are generally in the nature of localized areas of edema, organized clots, cysts, tumors (fibroma, glioma, malignant).

Scar tissue sources are connected usually with adhesions, but occasionally occur independently from a scar on the dura or cortex.

Onset.—The time-limit varies greatly, but usually the nearer the time of beginning to the injury, the greater the probability of relationship. This is particularly true in healthy adults whose family history, early life, habits, and physique are such as to indicate that the symptoms are unrelated to idiopathic or reflex epilepsy. In children, traumatic epilepsy is less likely because of their capacity to better withstand cerebral irritation owing to the elasticity of the skull, and also owing to the fact that the age of onset in ordinary epilepsy is usually in early life.

Symptoms.—Usually this type begins with evidences of focal irritation of the motor area, exhibited by such signs as twitching, spasms, or tonic convulsions of a part of the face or extremity (usually the fingers) on the side opposite to the lesion.

These irritative manifestations are known as *Jacksonian* or *focal epilepsy*. Consciousness is maintained, but auræ may occur and offer a clue to the probable site of trouble because of their relation to the sensory part of the Rolandic area; thus, *postcentral* involvement may be indicated by such paresthetic signs as numbness, tingling, burning, itching, or painful sensations in the region later convulsed; *occipital lobe* origination is indicated by visual sensations of colored or bright lights; *uncinate convolution* involvement by taste and smell impressions; *cerebellar* involvement by vertigo and ataxia signs; *aphasic* types by speech involvement.

Sometimes a unilateral convulsion may be the originating evidence, but usually there is a progression of symptoms from a limited twitching or spasm that invades adjacent cortical areas until the entire half of the face, limb, or trunk is the scene of a tonic convulsion that may become clonic as it advances, and occasionally invade the other half of the body. In some cases unconsciousness ensues, the tongue is bitten, and a generalized convulsion occurs, as in the idiopathic or reflex varieties; this grade of seizure, however, does not usually occur until the Jacksonian manifestations have existed a long time, and in these the differentiation from ordinary epilepsy is correspondingly more difficult.

"It is characteristic of many cases of focal epilepsy for the seizure to abort before the convulsion has involved the entire body and before consciousness is lost" (Cushing).

Occasionally the traumatic forms begin as "fainting spells" with temporary loss of consciousness (petit mal); and others may be ini-

tiated by auræ with generalized convulsions and unconsciousness (grand mal). This type with unconsciousness, as stated, is typical of ordinary or idiopathic or reflex epilepsy, and the Jacksonian manifestations are typical of traumatic forms, although unconsciousness may occasionally occur with the so-called *non-traumatic Jacksonian epilepsy.*

Epilepsy, or epileptoid manifestations, said to proceed from zones of injury remote from the brain, are probably invariably due to other sources; painful scars, stumps, and neuromata were at one time accused, but better knowledge has disproved this view.

Differentiation.—To be reliable, non-traumatic sources of origin must be excluded, and the *history* and *examination* of the patient are, therefore, of primal importance, bearing in mind that external evidences of head injury may have occurred at the time of the convulsion and not before it; and also that injury to the head is so common that patients, parents, and friends, because of pride or other personal reasons, are likely to look upon it as the producing factor, forgetting that the vast majority of cases are due to other and perhaps less apparent causes. A reliable family history is often obtained with difficulty, but the surgeon should inform those interested in the outcome that without a proper history little can be accomplished. The immediate family history is, of course, most important, but that of several preceding generations should be sought also.

Syphilis, alcoholism, and mental defects in the parents, and miscarriages, premature births, and the condition of other children should be subjects of inquiry. The manner of the patient's birth (instrumental or "dry"), convulsions in infancy, early feeding, dentitions and illnesses are inquired into. The nature of the accident and the succeeding symptoms and treatment are important; but more than all, the surgeon must be credibly informed as to the early signs of onset and the "march of symptoms."

If possible, the patient is observed in a convulsion, or intelligent parents are instructed to watch for certain symptoms of onset, taking care not to suggest the manifestations of a typical case. Obviously, adult patients, or those who remain conscious during a seizure, are often in the best position to narrate the occurrence, assuming that the mentality is unclouded.

Traumatic origin is given most weight if: (1) The preceding family and personal history is satisfactory. (2) The injury has been adequate as to extent, site, and sequence. (3) The symptoms are Jacksonian in type. (4) The onset is reasonably close to the time of injury.

(5) The examination discloses no other more reasonable source of origin. (6) The patient is a healthy adult over twenty-five years of age. (7) There is no epileptic facies, habitus, or other sign of chronicity. (8) There are no neuropathies or obvious defects physically, particularly of the sexual or internal glandular systems.

Treatment.—To be effective this must be limited to carefully selected cases, preferably those in whom the "epileptic habit" has not been established by a long continuance of symptoms.

The object is by exploration to remove apparent sources of cortical irritation, and when practicable a bone-flap should be turned down so that a reasonably wide area can be exposed. Faradic stimulation may become a necessary guide to indicate the involved area, as this ordinarily responds more promptly and violently than the normal cortical zone; stimulation also aids in more accurately determining the topography.

Involved portions may present adhesions, surface irregularities, changes in color or superficial circulation, or definite tumors of solid, semisolid, or fluid consistency. Manipulation must be as gentle as possible and great care is taken to leave the field absolutely dry so that fresh adhesions may not form.

In cases in which a cranial defect does not already exist, the question of making one for decompression purposes will depend upon the amount of intracranial pressure; if this is great, a portion or all of the bone-flap may be exsected. In some cases a decompression is done on the opposite side to afford better relief from tension, after the manner of Kocher.

Bilateral removal of the superior cervical sympathetic ganglia is advised by Jonnesco, and exsection of layers of the cortical area is advised by others.

The usual procedure is the formation of a bony defect and the removal of apparent adhesions or growths.

Results.—Many of the cases operated upon with every hope of finding obvious cause for symptoms prove disappointing, as no gross lesion is discoverable after careful search and exploration.

Cushing states that of 128 cases referred to him in five years as suitable for operation, he rejected all but 59 as unsuitable. Of these, 40 had focal and 19 general attacks; 20 cases were "following traumatisms in the adult," and the others were due to birth palsies, tumors, meningitis, adhesions, hydrocephalus, hemorrhagic pachymeningitis, syphilis, and "idiopathic" causes with focal symptoms. Of these 59, 12 have remained free of attacks from one to five years; of the re-

mainder, 30 assert they are "greatly improved," and 17 showed no improvement and 2 have died in *status epilepticus*.

These statistics are similar to those of M. A. Starr.

Many operated cases are temporarily benefited, probably due to alteration in cerebral circulation or change of habits and outlook, and some cases appear to be rendered more amenable to medicinal and hygienic regimen.

If postoperative bleeding occurs there will usually be monoplegic or other evidences of cortical hemorrhage, but these subside on absorption of the clot; but there is always the likelihood of re-establishment of adhesions unless the operative field is left wholly bloodless.

Insanity and the Psychoses

It is often difficult to determine if the mental disturbance is wholly, partly, or at all related to the injury, and in this respect such alleged complications have to be weighed as carefully as in epilepsy.

The time and manner of onset and the associated evidences of neural or constitutional disturbances are quite important. A Wassermann reaction and the examination of the fluid obtained by lumbar puncture (spinal tap) often determine the exact nature and origin of symptoms. These reliable diagnostic aids should be final parts of a carefully conducted neurologic examination, preferably made with the co-operation of a neurologist in doubtful cases.

Symptoms of mental disturbance may follow the manifestations named under the psychoses, appearing soon after the accident (primary or immediate), or after a lapse of years (secondary or remote). Obviously, this last group is less likely to stand in causal relationship, especially if they occur at a time of life when arteriosclerotic, senile, or constitutional effects of vicious habits are likely to become prominent. Alcoholism, physical and mental strain, and other predispositions are also to be considered as possible factors.

Bailey states that traumatism to the head can be regarded as responsible in only 2 per cent. of insanity cases even in the presence of marked evidences of cerebral injury.

Krafft-Ebing (quoted by Eisendrath) states that these late or remote psychical changes are divisible into three groups: The *first* is characterized by feeble-mindedness and idiocy, associated with in-co-ordination and paralysis; the *second* eventuates from a long preliminary stage of mental irritability and change of character, followed by mania and progressive paralysis; the *third* seems to have only an indirect relationship to the injury and develops as the result of associ-

ated or accompanying causes. The severer forms of head injury (extensive vault and basal fractures, hemorrhages, infections, contusions, and lacerations) are the type ordinarily suspected. Many of these cases occur in alcoholics with or without delirium tremens.

The Psychoses

Many of these are of the subjective type and often in the nature of "hysteroneurasthenia," "traumatic neurasthenia," or "post-traumatic neuroses."

Early manifestations may present as memory defects, headache, nausea, vertigo, and more or less mental apathy. This state may become more or less active, with delirium, delusions, disorientation or hallucinations, and restraint may be necessary.

Some of these cases are the outgrowth of secondary edema or more or less localized serous meningitis, especially if there has been no decompression from the injury or operation.

Most of these go on to recovery.

Later manifestations may be the outgrowth of the preceding or occur after apparent recovery, notably in patients who are not subjected to a reasonable period of enforced rest and quiet, or in those who too quickly return to work or former habits. These patients are restless, nervous, and often refer to painful or paresthetic areas near the suspected site of injury. Their speech, habits, and character are sometimes changed; they may be readily disturbed by trivial occurrences, or become imaginative, irascible, introspective, moody, suspicious, and sometimes violent. Their mental processes may be interfered with and they become incapable of sustained effort. Memory for figures, dates, and recent or remote occurrences may be deficient, and peculiar aversions to persons or things may occur. Intolerance to alcohol and tobacco may exist, and "one drink sets them off." The majority of the symptoms are *subjective*, but there are nearly always *objective verifications*, notably: changes in the superficial and deep reflexes (ordinarily showing exaggeration), increase of pulse, ataxia, sweating, alternate blushing and pallor, cold extremities, tremors of the tongue, closed eyelids or fingers, hyperesthetic areas on skull or spine, and changes in the appearance. Fever is usually absent. Marked cases sometimes develop insanity.

Some of these cases are more or less conscious malingerers and many of them do not recover pending litigation.

Treatment.—The preliminary management is very important, and, as already stated, no case of manifest head injury should be denied

adequate observation and reasonable rest until all symptoms of irritability and definable trouble subside. Alcoholics are guardedly treated from the outset and warned against drinking.

The *psychoses* are best treated by isolation and rest, and it is especially necessary to restrain well-meaning but misguided friends from suggesting lines of treatment. The patient can have the assurance that these symptoms subside in time, assuming them to be of the ordinary functional type without organic basis.

In a general way, the management of this sort of case resembles that of traumatic hysteroneurasthenia (see page 699).

The *insanities* are given the benefit of decompression if there are indications suggesting intracranial pressure or irritation as a definite or focal cause. In some instances, as in tumor formation and foreign bodies, radiographic examination is helpful. When operative indications are apparently absent in that group in which trauma seems the only adequate cause, it is justifiable to give the patient the benefit of an exploratory craniotomy. Some cases do better under asylum regimen, and violent, delirious, or otherwise irresponsible patients are carefully watched in the hope hat focalizing tell-tale symptoms may indicate a site for surgical procedure.

However, no case should be subjected to operation until tests of the blood and cerebrospinal fluid exclude syphilis.

CHAPTER XII

INJURIES OF THE SPINE

THERE are two general classifications (as in the cranium, thorax, and abdomen) depending upon the presence or absence of damage to the spinal cord, and hence we speak of (1) *extraspinal*, and (2) *intraspinal* types of involvement.

(1) *Extraspinal Types.*—Spinal column: Contusions, sprains, lacerated ligaments, dislocations, and fractures.

(2) *Intraspinal Types.*—Hemorrhage, inflammation (meningitis, myelitis), and fracture-dislocation.

The foregoing types are often combined, resulting in extra- and intraspinal grouping of symptoms.

Anatomy.—The *spinal column* or *spine* is a bony box made up of 33 flexibly joined segments or *vertebræ:* 7 of these are known as *cervical*, 12 as *dorsal*, 5 as *lumbar*, 5 as *sacral*, and 4 as *coccygeal.* The average length of all the vertebræ is about 27 inches.

Each vertebra is made up of a strong anterior portion called the *body*, and a posterior portion called the *arch*, the latter being composed of various prominences known as **processes** or **pedicles,** the *body* and *arch* joining by the **laminæ.**

The respective vertebræ are very closely bound to each other by strong ligaments and they are surrounded by massive muscles. The hollow interior of the spine houses the *spinal cord* (or cord), which is a cable of nerves serving to transmit neural messages to and from the brain. This cylindric cord is suspended in this *spinal canal*, beginning above in the *medulla* at the upper border of the atlas, and ending below at the lower border of the first lumbar vertebra, and thereafter it becomes a slender ribbon of gray matter, called the *filium terminale*, reaching to the second coccygeal vertebræ.

The cord weighs about 28 gm., averages 18 inches long, and hangs pendulum-like in the spinal canal, occupying only about two-thirds of the available space therein.

It is covered by three membranes known as the *spinal meninges.* The outer investment is the *dura*, which does not come into contact with the spinal canal, as the latter has a periosteum of its own. The

central investment is the *arachnoid*, which is a continuation of that of the brain forming a sheath for the spinal nerves. The outer surface of this layer is to some extent connected with the dura, the intervening portion being known as the *subdural space;* its inner surface is separated from the pia by the *subarachnoid space*, and this is filled by the *cerebro-spinal fluid*. The inner investment is the *pia*, which is intimately attached to the cord, forming its neurilemma and also sending a process into its anterior fissure.

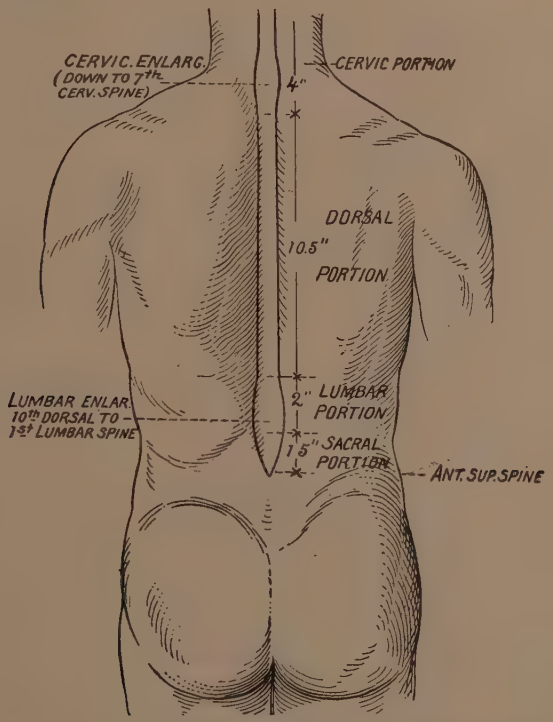


Fig. 452.—Spinal cord, showing the location and length (in inches) of the respective portions.

The size of the cord is quite uniform throughout except for two areas known respectively as the *cervical enlargement* (at the junction of the cervical and dorsal portions) and the *lumbar enlargement* (at the junction of the dorsal and lumbar portions). These enlarged areas correspond to the places where the cord distributes and receives nerves from the upper and lower extremities respectively (Fig. 452).

Spinal Nerves.—Passing laterally from the cord to the intervertebral foramina are 31 pairs of spinal nerves: 8 of these are from the cervical, 12 from the dorsal, 5 from the lumbar, 5 from the sacral, and 1 from the coccygeal region. The uppermost nerve is placed between

the occiput and the axis; the lowermost, between the first and second portions of the coccyx.

Each spinal nerve arises by two roots, an *anterior* or *motor*, and *posterior* or *sensory root*. On each of the latter (just prior to uniting with the former to escape from the spinal canal) is a distinct swelling known as the *spinal ganglion*, and the function of this is trophic for the afferent tracts. After the roots unite they are known as *mixed nerve trunks*, and their site of exit does not correspond with their place of origin, as they traverse the cord vertically before escaping, as will be seen from the illustration. This is most marked in the lumbar and

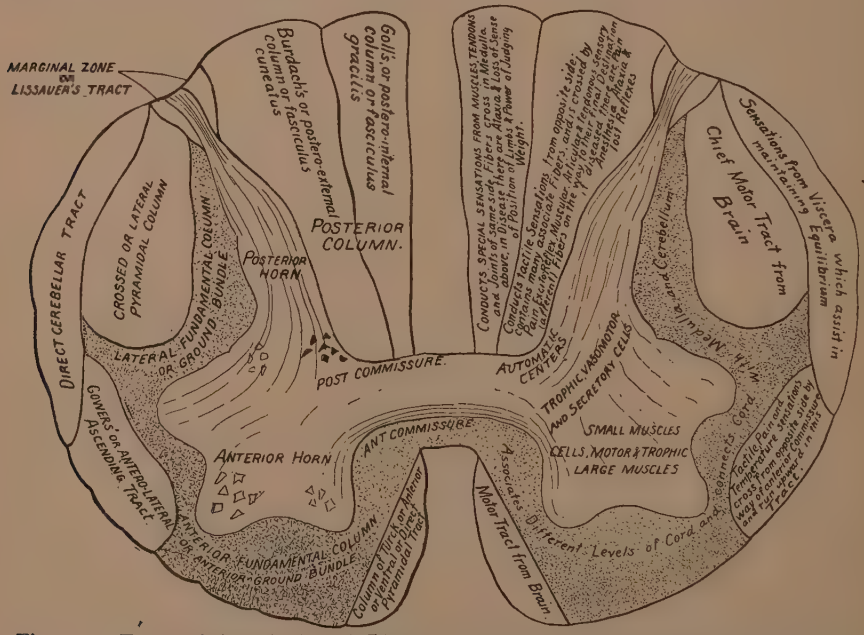

MARGINAL ZONE OR LISSAUER'S TRACT
Burdach's or postero-external Column or Fasciculus Cuneatus
Goll's or postero-internal Column or Fasciculus Gracilis
POSTERIOR COLUMN.
DIRECT CEREBELLAR TRACT
CROSSED OR LATERAL PYRAMIDAL COLUMN
POSTERIOR HORN
LATERAL FUNDAMENTAL COLUMN OR GROUND BUNDLE
POST COMMISSURE
AUTOMATIC CENTERS
TROPHIC VASOMOTOR AND SECRETORY CELLS
Chief Motor Tract from Brain
Sensations from Viscera which assist in maintaining Equilibrium
SMALL MUSCLES
CELLS, MOTOR & TROPHIC
LARGE MUSCLES
ANT COMMISSURE
ANTERIOR HORN
GOWERS' OR ANTERO-LATERAL ASCENDING TRACT
ANTERIOR FUNDAMENTAL COLUMN OR ANTERIOR GROUND BUNDLE
Column of Tract of Marie or Direct Pyramidal Tract
Motor Tract from Brain
Associates Different Levels of Cord
Connects Cord

Fig. 453.—Tracts of the spinal cord: Light spaces = motor (or efferent); dark spaces = sensory (or afferent) (modified from Butler).

sacral nerves, and here the *filium terminale* is enveloped by a mesh of nerves called the *cauda equina* (horse's tail).

If a cut section of the cord is examined it will be seen to be cylindric and broader from side to side than from before backward. It will show a *central canal* and be divided into nearly equal halves by a deep broad *anterior fissure* (or septum), and a shallow narrow *posterior fissure* (or septum). Gray matter in an **H**-form occupies the interior portion and white matter the external portion. Each prong of the **H** is known as a *horn*, and hence arise the terms *anterior horns* or *columns*, and *posterior horns* or *columns*. The lateral projection of gray matter is known as the *lateral horn* or *column* (Fig. 453).

Spinal Topography

As indicated, the **H**-shaped gray substance delimits various *columns* or *horns*, dividing the cord into an *anterior*, *lateral*, and *posterior* portion. In addition, the cord is further segmented by the levels at which the various spinal nerves escape, determined by their relation to the spinous processes; hence there are 31 segments.

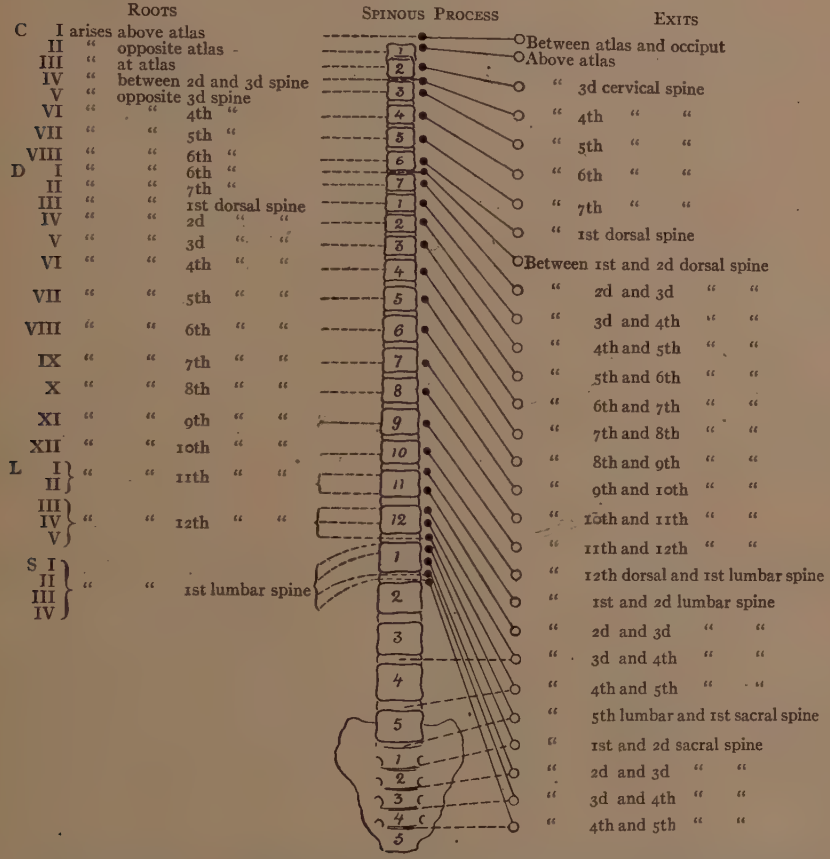

Roots
Spinous Process
Exits
C I arises above atlas
II " opposite atlas
III " at atlas
IV " between 2d and 3d spine
V " opposite 3d spine
VI " " 4th "
VII " " 5th "
VIII " " 6th "
D I " " 6th "
II " " 7th "
III " " 1st dorsal spine
IV " " 2d " "
V " " 3d " "
VI " " 4th " "
VII " " 5th " "
VIII " " 6th " "
IX " " 7th " "
X " " 8th " "
XI " " 9th " "
XII " " 10th " "
L I, II " " 11th " "
III, IV, V " " 12th " "
S I, II, III, IV " " 1st lumbar spine
Between atlas and occiput
Above atlas
" 3d cervical spine
" 4th " "
" 5th " "
" 6th " "
" 7th " "
" 1st dorsal spine
Between 1st and 2d dorsal spine
" 2d and 3d " "
" 3d and 4th " "
" 4th and 5th " "
" 5th and 6th " "
" 6th and 7th " "
" 7th and 8th " "
" 8th and 9th " "
" 9th and 10th " "
" 10th and 11th " "
" 11th and 12th " "
" 12th dorsal and 1st lumbar spine
" 1st and 2d lumbar spine
" 2d and 3d " "
" 3d and 4th " "
" 4th and 5th " "
" 5th lumbar and 1st sacral spine
" 1st and 2d sacral spine
" 2d and 3d " "
" 3d and 4th " "
" 4th and 5th " "

Fig. 454.—Relation of the spinal segments and of the roots and places of nerve exit to the spinous processes. Dots indicate points of origin. Circles indicate points of exit. C = cervical; D = dorsal; L = lumbar; S = sacral (modified from Butler).

The seventh cervical vertebra (*vertebra prominens*) is the determining bony landmark in the upper portion; the twelfth dorsal vertebra (indicated by the corresponding rib) denotes the mid-portion; and the fourth lumbar vertebra (denoted by being on a level with the crests of the ilia) is the landmark for the lower portion. Reference to Figs. 454–456 will best indicate these relations.

Practically speaking, to determine the number of a given nerve-root at any level, we may in the cervical region add *one* to the spinous process at the place of exit; in the upper dorsal region we add *two;* and add *three* in the lower dorsal; in the lumbar region we add *four*. In children under seven, we add *three* to the number of the spinous process up to the mid-dorsal, and add *four* below that level (Chipault).

Cord lesions are thus located above the level of their spinal nerve symptoms.

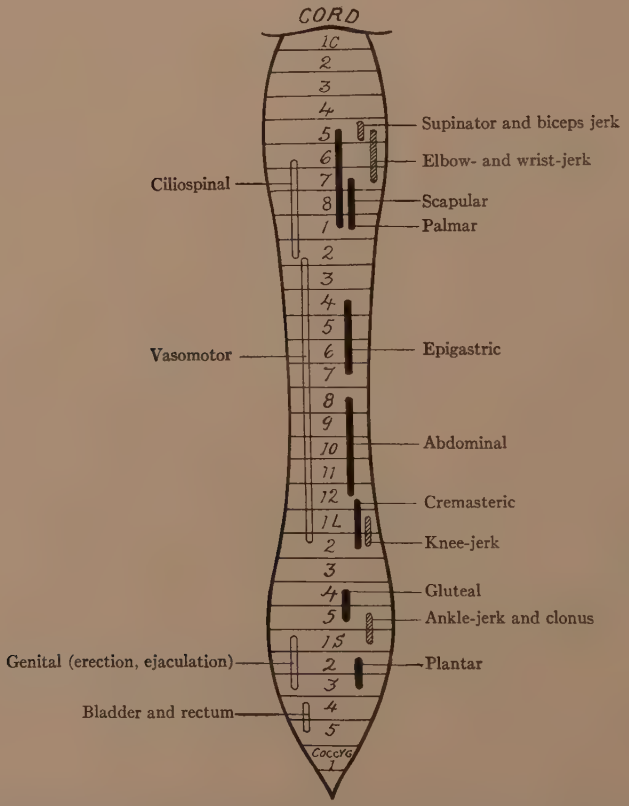


Fig. 455.—Spinal segmental localization of the automatic centers and the superficial and deep reflexes. Superficial reflexes, ▯ ▮; deep reflexes, ▮ (after Butler).

The total number of anterior root-fibers in a woman of twenty-six is 303,265; the posterior root-fibers numbered 504,473 (Stilling).

Each segment of the cord, as stated, consists of a mass of gray matter surrounded by a series of white tracts from which a pair of spinal nerves pass out. These segments intercommunicate with each other and are also connected with the brain by various *tracts* or *columns* of white matter; hence each segment is a center and also a means of

transmitting impulses to more or less distant parts. Each of the 31 segments is composed of symmetric halves, each of which receives two afferent (sensory) and gives off two efferent (motor) nerves; the former are in the posterior and the latter in the anterior portion of the cord. Each segment, therefore, possesses motor function (anterior roots), sensory function (posterior roots), and various reflex, vasomotor, and trophic functions.

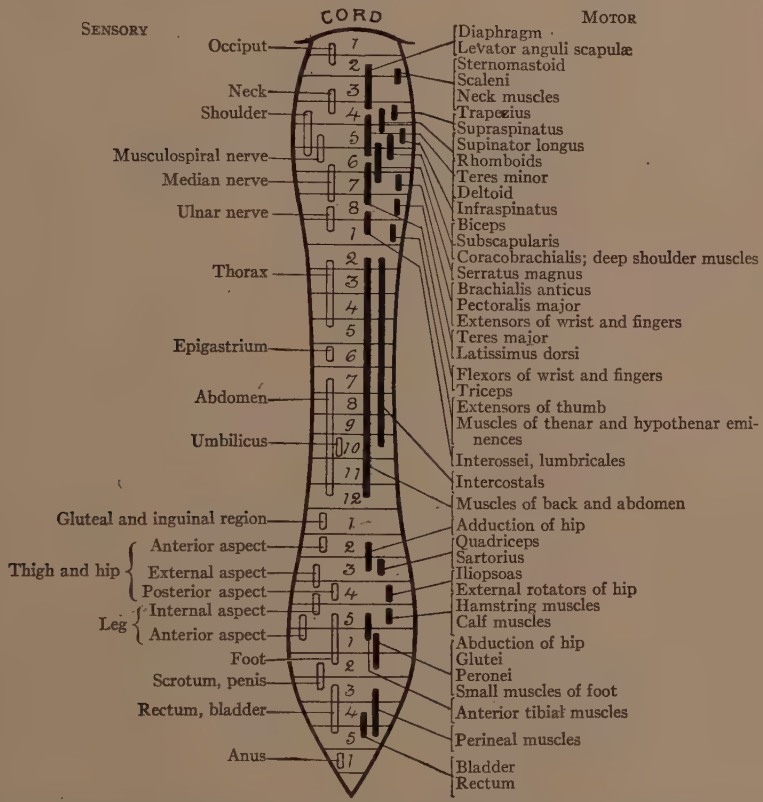


Fig. 456.—Location of spinal segments controlling sensation and motion (after Butler, based on Jakob (sensory), and Starr, Mills, Sachs, and Dana (motor)).

The relation of these spinal segments to sensation and motion has been carefully determined and is as denoted in the diagrams.

The function of the respective *tracts* and columns is also diagrammatically shown (see Fig. 453).

The *blood-supply* of the cord is by an *anterior* and *posterior* set of vessels, the arterial twigs of which do not anastomose after penetrating the cord. The spinal arteries are, for their size, the longest in the body,

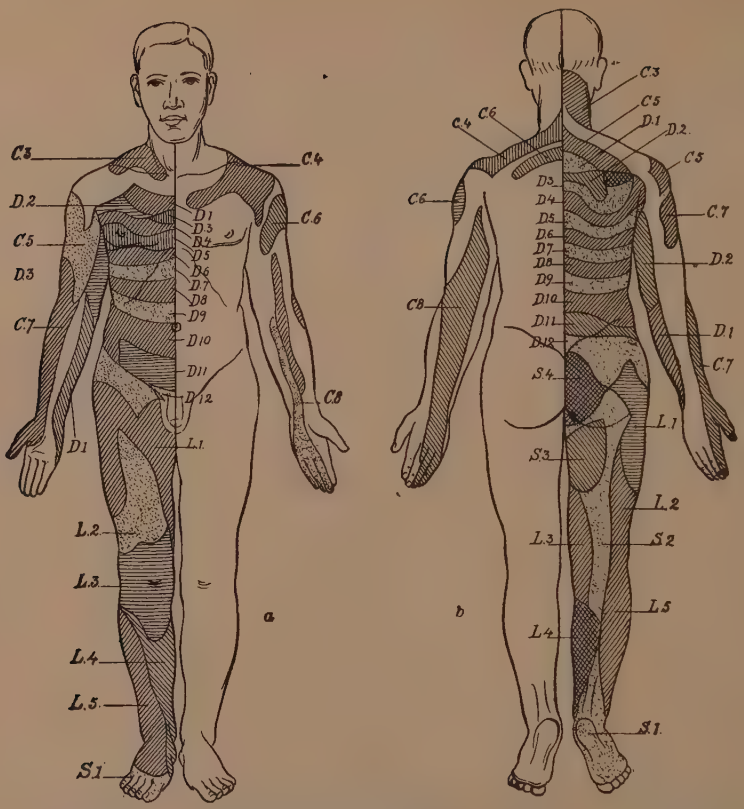


Fig. 457.—Cutaneous sensory nerve-supply in relation to respective spinal segments: *a*, Anterior surface; *b*, posterior surface.

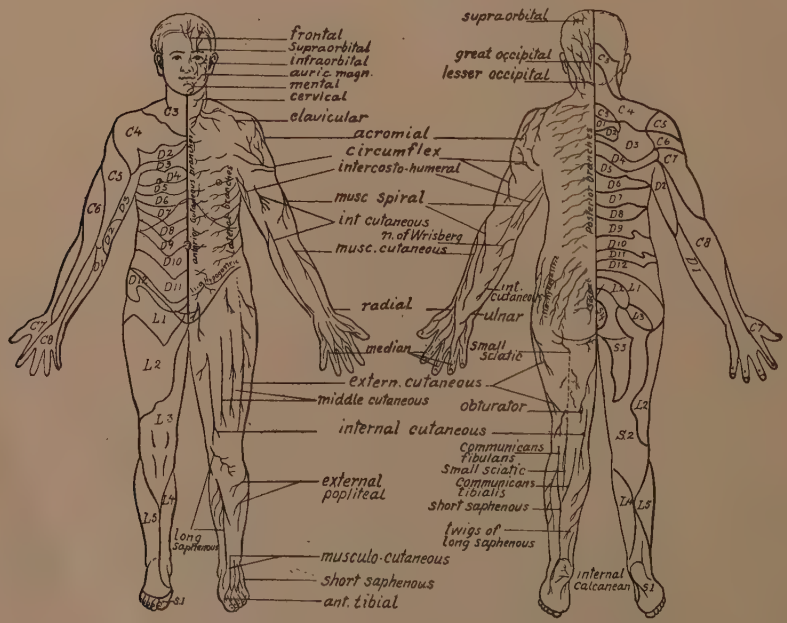


Fig. 458.—Cutaneous nerves and their segmental relationship.

and they are not subjected to cardiac impulses and the pressure within them is very slight.

The *manifestations* of cord lesions are *irritative* or *destructive*, depending upon the site and extent of the injury, and they become manifest as related to the *vertical* or *horizontal* planes of the cord.

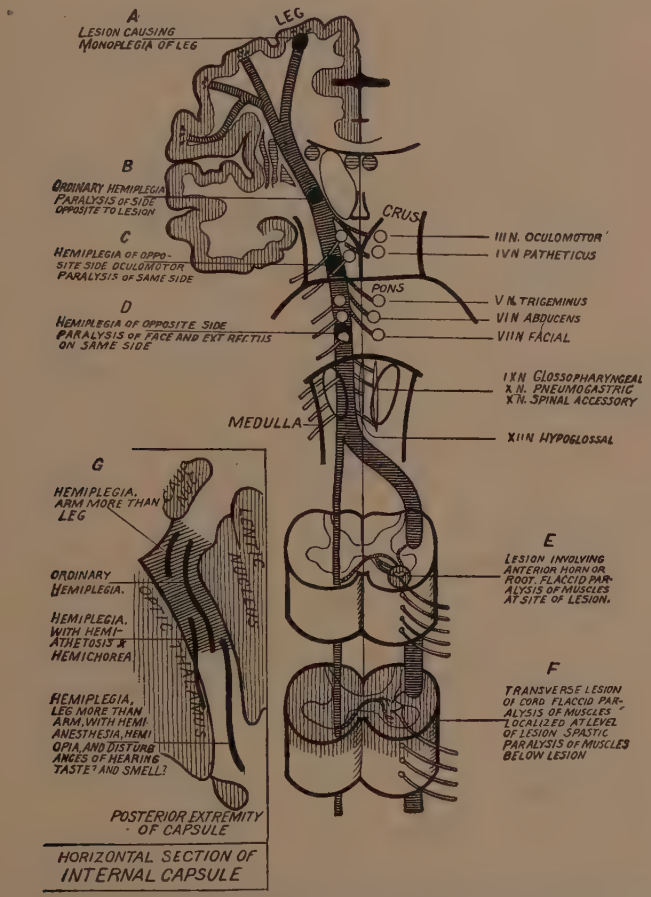

A
LESION CAUSING MONOPLEGIA OF LEG
LEG
B
ORDINARY HEMIPLEGIA PARALYSIS OF SIDE OPPOSITE TO LESION
C
HEMIPLEGIA OF OPPOSITE SIDE OCULOMOTOR PARALYSIS OF SAME SIDE
D
HEMIPLEGIA OF OPPOSITE SIDE PARALYSIS OF FACE AND EXTREMITIS ON SAME SIDE
CRUS
III N. OCULOMOTOR
IVN PATHETICUS
PONS
V N. TRIGEMINUS
VI N ABDUCENS
VII N FACIAL
IX N GLOSSOPHARYNGEAL
X N. PNEUMOGASTRIC
XI N. SPINAL ACCESSORY
MEDULLA
XII N HYPOGLOSSAL
G
HEMIPLEGIA, ARM MORE THAN LEG
ORDINARY HEMIPLEGIA.
HEMIPLEGIA, WITH HEMI-ATHETOSIS & HEMICHOREA
HEMIPLEGIA, LEG MORE THAN ARM, WITH HEMI-ANESTHESIA, HEMI-OPIA, AND DISTURBANCES OF HEARING TASTE? AND SMELL?
LENTIFORM NUCLEUS
OPTIC THALAMUS
POSTERIOR EXTREMITY OF CAPSULE
HORIZONTAL SECTION OF INTERNAL CAPSULE
E
LESION INVOLVING ANTERIOR HORN OR ROOT. FLACCID PARALYSIS OF MUSCLES AT SITE OF LESION.
F
TRANSVERSE LESION OF CORD FLACCID PARALYSIS OF MUSCLES LOCALIZED AT LEVEL OF LESION SPASTIC PARALYSIS OF MUSCLES BELOW LESION

Fig. 459.—Effect of lesions (indicated by circles) of the motor path in the brain and spinal cord: *G*, Internal capsule lesions and the variation in symptoms due to their antero-posterior position (modified from Butler).

Vertical lesions of a *motor* type vary between paralysis and irritative evidences, as denoted by spasms or rigidity. It is to be recalled that a segment supplies many muscles, and, therefore, paralysis or involvement of a *single* rather than a *group* of muscles is evidence that the lesion is peripheral or distal and not spinal or central.

Lesions of the *sensory* type vary from complete anesthesia to altera-

tions in sensation. *The summit of the anesthesia is ordinarily the best guide as to the level of the lesion*, and this anesthetic area is often surmounted by a ridge, band, or girdle of hyperesthesia (Figs. 457–461).

Reflexes are wholly abolished in complete lesions at and below the level of the damage; but later the reflexes increase.

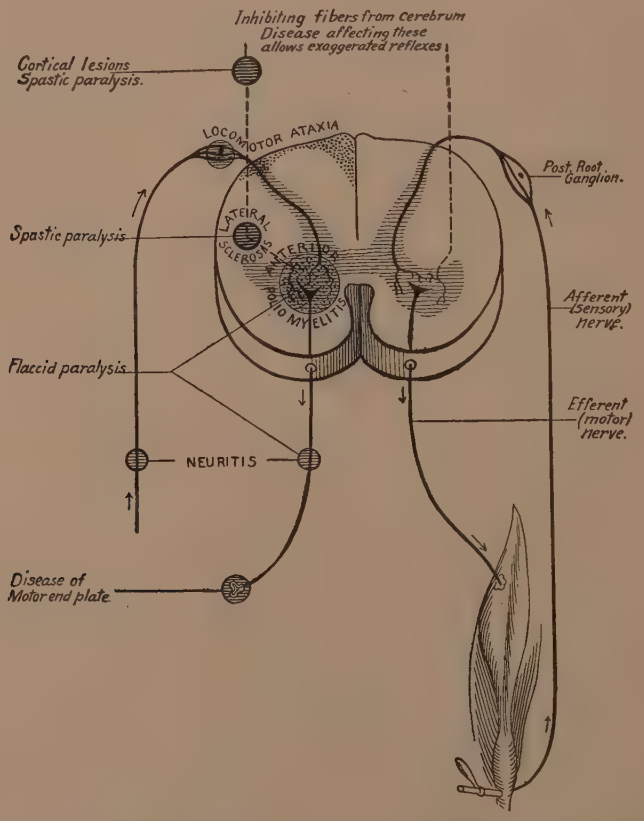


Fig. 460.—Mechanism of the deep reflexes and the two main types of paralysis (spastic and flaccid). Dark circles indicate lesions giving exaggerated reflexes. Light circles indicate lesions giving abolished reflexes (modified from Butler).

The upper level of the abolition of reflexes usually coincides with the anesthesia, and the determination of both gives adequate information as to the level of damage.

Trophic centers for muscle correspond to their motor spinal centers in the anterior horns, and any destructive lesion of this portion of the gray matter causes *atrophy* of the supplied muscle group. The muscles deriving their nerve-supply above and below the lesion are unaffected.

This can be best understood by reference to the annexed table (see page 506).

The earliest signs of muscle involvement are indicated by a loss of tone with softening and flabbiness; later, shrinkage and the reaction

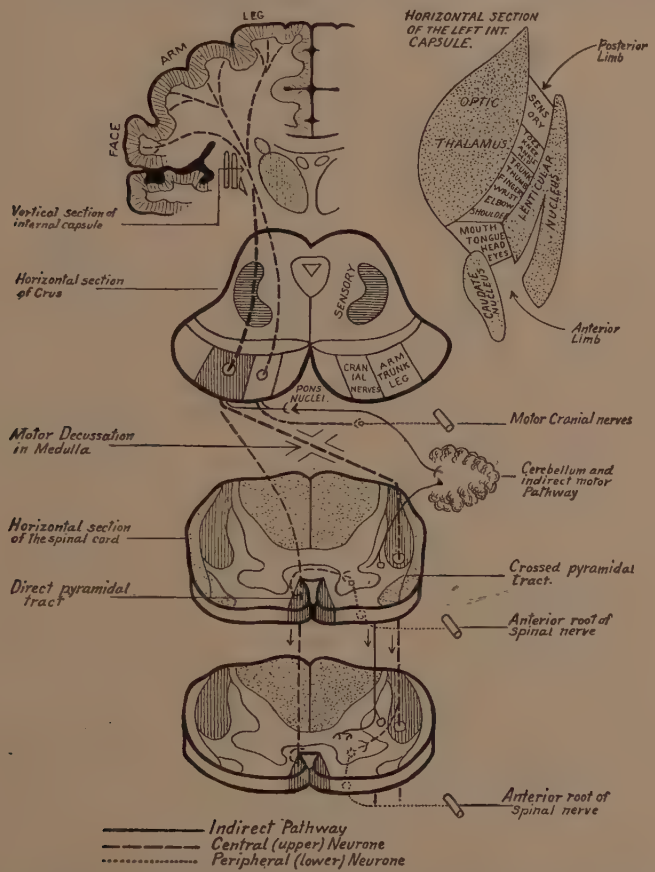


Fig. 461.—Spinal cord motor pathways. *Indirect pathway* (denoted ————) for muscular co-ordination and higher reflex and automatic movements, runs from cortex to pons nuclei, to cerebellum, to lateral fundamental column, via the peduncles, the fibers ending in the lateral horn. *Direct pathway* (denoted – – – –) for voluntary impulses, runs from cortex, via corona radiata, internal capsule, crus, pons, medulla, crossed and direct pyramidal columns, to motor cells of anterior horn. *Cranial nerve motor fibers* (denoted .....) cross at various levels in crus, pons, and medulla (modified from Bailey).

of degeneration appear. Such isolated changes are best illustrated in the extremities and about the main joints. The loss of tone in the skin becomes manifest by a change in its texture so that it may become glossy and shiny, and later may become dusky, cyanosed, dry, and scaly. Slight pressure is capable of inducing ulceration and thus *bed-sores* are

formed; they occur most often over the sacrum, malleoli, heels, buttocks, and other places subjected to posture pressure.

Vasomotor changes may show in the *pulse-rate;* in dorsal lesions a rapid pulse is rather constant, but the reverse pertains in cervical injuries. In the latter, unilateral or more or less symmetric *sweating* occasionally occurs. The *skin* at first may be quite flushed and warm, but later is cold and livid. Changes in temperature usually indicate septic states. *Visceral* changes relate chiefly to the bowels and bladder. If these centers in the lumbar segment are involved, there is complete incontinence of feces and urine; if the lesion is above these centers, then voluntary control alone is lost and automatic action allows their function to be unconsciously performed. If this last condition exists, the anal sphincter can still contract on the examining finger, but it cannot do so when the center is involved. Retention of urine and feces may occur, and in the case of the bladder this may lead to inflammatory changes that may later extend to the kidneys. *Cystitis* to some extent is a common sequence, and becomes a very grave menace unless every precaution is taken during catheterization to prevent infection that speedily may induce septic kidney and death.

HORIZONTAL LOCALIZATION

Some lesions affect the cord in the transverse rather than the vertical axis, and these may be symmetric or otherwise.

Pyramidal tract lesions cause—

Paralysis: Motor spastic type below the involved level.
Reflexes: Exaggerated, with rigidity and contractures.
Degeneration: Downward.

Posterior columns and horn lesions cause—

Sensation: Disturbed, especially temperature, pain, pressure, muscle, and joint sensations.
Ataxia: Present.
Reflexes: Absent or much diminished.
Degeneration: Upward.

Posterior root lesions cause—

Sensation: Anesthesia in total involvement; hyperesthesia and radiating pain if otherwise.

Anterior horn and root lesions cause—

Paralysis: Motion abolished in muscles involved and atrophy occurs.
Reflexes: Abolished and the reaction of degeneration is present.
Degeneration: Downward.

Central canal lesions cause—

Sensation: Dissociation with preservation of touch and loss of painful and thermal sensations.

Half of transverse segment lesions cause—

Paralysis: Motion lost on same side as, and at and below, the level of damage; slight loss of power on opposite side (usually).

Sensation: Complete loss on opposite side at and below the level of damage. (See Fig. 459.)

(This is the *Brown-Séquard paralysis.*)

Cauda Equina Lesions.—The cauda is about 10 inches long and reaches downward from the first lumbar vertebra, and hence any cord injury in this vicinity is a nerve-root lesion of the descending roots of the lumbar, sacral, and coccygeal nerves that comprise it. The manifestations are, generally speaking, the same as would be produced by injury to the lumbar or sacral plexus. The reflexes are not increased and visceral control is not affected in true caudal lesions.

As already indicated, the flexible spinal column with its strong padding of muscles and ligaments affords almost armored protection to the contained cord, and the latter itself receives added safety by floating in cerebrospinal fluid and by being enveloped in its own three membranes. For this reason unusual localized violence is necessary to produce injury of the cord itself, but lesser degrees of violence may affect the parts external to it.

Extraspinal Types of Injury

There are no cord symptoms in this group.

CONTUSIONS

These consist of bruises of the soft parts, or of the *erector spinæ* muscle mass due to *direct violence*, as from blows or falls.

Symptoms.—These do not differ from those of ordinary contusions, except that ecchymosis may be diffuse and rather late in onset and slow in disappearance. Hematoma formation is rare because the muscle and fascial planes are so firmly connected. Pain on motion is marked enough at times to cause a typical attitude in walking resembling that described in Traumatic Lumbago (see page 508).

Treatment.—Hot or cold applications are used at first (water, alcohol, or lead and opium), and later several criss-crossed adhesive straps are applied. If necessary, the counterirritation of iodin, turpentine,

electricity, the cautery, or vibration may be tried. Anodynes will be needed sometimes, especially in rheumatics and where a "lame back" is complained of despite ordinary external treatment.

SPRAINS AND LACERATED LIGAMENTS

Sprains refer to the sudden wrenching or stretching of ligaments between the vertebræ, usually those connecting the spinous processes; if this is extreme, the fibers may be torn and then laceration is said to exist.

Causes are almost invariably sudden forms of indirect violence resulting in forward or lateral bending of the spine, as from twists, falls, crushes, and the like.

Chronic forms are generally postural from occupations demanding stooping or bending positions; many of these in time show bony curvature in association.

Symptoms.—Local pain on pressure or motion is the main feature, and this is increased by movements that impose strain in the region of the stretched or torn ligaments. Usually the mid-portion of the back presents the maximum tenderness, and at no time is the pressure pain distant more than a few inches from the spinous processes. Swelling and discoloration are added signs. Mobility between spinal segments is never found because the adjacent interlacing of muscle and fascia is quite sufficient to maintain contour even in the presence of direct severing of many ligaments. The cervicodorsal, dorsolumbar, and lumbosacral regions are most commonly affected. In some instances, radiating pain may be present along the intercostal and lateral abdominal regions.

Sprains in the lumbar region are common enough to be denoted by the term *traumatic lumbago;* the symptoms resemble spinal ligament sprain elsewhere except that the back is held rigid and somewhat arched and the patient assumes this stiff characteristic attitude in walking, rising, and sitting.

Treatment.—Rest and anodynes summates this. The former is best provided by adhesive plaster criss-cross dressings, these to be applied at once or after the preliminary use of hot fomentations of alcohol and water, lead and opium, or other embrocations. Codein, aspirin, salicylates, and other appropriate drugs are given as required, these last being especially suitable in rheumatics. Later, counter-irritation from iodin, electricity, vibration, the actual cautery, ironing with a flat-iron, or massage may be necessary. Hot baths followed by brisk massage will also aid in "limbering up lame backs."

Very rarely it may be expedient to apply a spinal brace of metal or leather, or a plaster-of-Paris jacket. This last form of treatment is most applicable in chronic sprain or rebellious lameness of the back due to habitual posture or constitutional causes.

"Pain in the back" and "lameness of the back" may arise from so many conditions that the physician must be on guard for non-traumatic causes in those cases that do not promptly respond to treatment that is efficacious in the large majority of acute cases due to injury. In women it is well to remember that pelvic disorders frequently are a source of pain in the back. Intra-abdominal causes must not be forgotten, such as gastro-intestinal and kidney ptosis. Finally, neurasthenia, hysteria, rheumatism, lumbago, neuritis, and a variety of other causes are to be excluded in persistent cases.

In differentiating sites of real from assumed pain, much aid is afforded by marking places of alleged tenderness along the spinal column and later asking the patient to relocate these areas when similar pressure is made upon them. Traumatic sources of origin are likely to be localized to one vertebra or vertebral segment; non-traumatic sources are generally so diffused, with intervening normal segments of such wide separation, that trauma could not be the source of such an uneven distribution. When previously marked areas cannot be relocated with reasonable accuracy, the trouble is probably more mental than physical, especially if there is the added corroboration of normal gait, rising and sitting ability, and little or no limitation of spinal motion.

It has been stated that pressure over a painful area increases the pulse-rate (Mannkopf's test), but I have not found this of much diagnostic importance in this or any other class of injury.

DISLOCATION OF THE SPINE

(See pages 191–201).

FRACTURE OF THE SPINE

Recognizable fracture without some coincident cord damage is relatively rare and is practically limited to lesions of the arches, mainly the spinous and transverse processes.

Causes and Varieties.—*Direct violence*, as from missiles, bullets, blows, or falls is an uncommon factor.

Indirect violence, due to forced forward or lateral bending with more or less added *muscular violence* is the usual source.

Ordinarily but one vertebra is involved.

When the *spinous process* is avulsed, it is usually broken at its base, and the adjacent portion of the arch may be detached with it.

The amount of separation varies, but it may be extreme and associated with considerable lateral or downward displacement. Cleavage at the tip of a spinous process is a not uncommon associate of sprains, thus becoming an example of sprain-fracture.

The *bodies* and *laminæ* rarely suffer in the absence of intraspinal complications, and the diagnosis of any such conditions would be impossible without *x*-ray verification.

Symptoms.—*Swelling*, *deformity*, *ecchymosis*, *local tenderness*, *false motion*, and *crepitus* are readily obtainable in typical cases. *Back bending* is painful and the adjacent muscles are rigid and tense. Local and radiating pains may occur. There may be associated injury at the costovertebral angle or elsewhere.

Treatment.—Adhesive plaster strapping will suffice for the average case; but if there is undue mobility of the column it is better to apply a plaster-of-Paris jacket, the spine being arched during its application. If a broken spinous process is unduly movable or threatens to protrude through the skin, it can be anchored by a few kangaroo tendon sutures introduced into the adjacent processes through a small incision. I recently employed this procedure in a case of dislocation of the first and second lumbar vertebræ with fracture of the spinous transverse processes of the first lumbar vertebra. This patient attempted to commit suicide by jumping out of a window, and her freedom from intraspinal injury appeared ascribable to an old curvature of the spine that in a way was forcibly corrected by her accident. She had no cord symptoms whatever.

Results.—Union of a spinous process is by fibrous tissue and is reasonably firm in three weeks, but some support should be worn for about two months. The outcome is necessarily good inasmuch as there is no damage to anything except the bony outcroppings of the column, and their intraspinal ligamentous and muscular attachments.

Intraspinal Types of Injury

There are cord symptoms in this group.

Spinal Hemorrhage

This may be *extradural* (*hematorachis*) or *intradural* (*hematomyelia*).

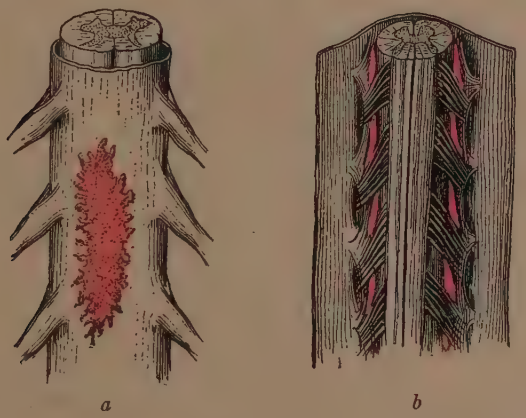
Extradural Hemorrhage; Hematorachis; Extramedullary Hemorrhage.—By this is meant an effusion of blood on the outside of the

spinal cord coverings and between them and the bone; it corresponds to that form of cerebral hemorrhage having the same name. It is relatively rare as compared with the other form of spinal hemorrhage, but both varieties coexist in severe and usually fatal cases (Fig. 462).

Causes.—It is always an associate of fracture or fracture-dislocation and does not occur as a separate entity, and hence the etiology is the same as that of fracture-dislocation.

It is conceivable that it might also occur from glancing or superficial penetrating agencies, such as a bullet or cutting instrument; obviously such a limitation would be rare. Occasionally it occurs also from spinal puncture made for diagnostic or therapeutic purposes.

Symptoms.—These are transitory and extremely difficult to recognize in the absence of direct inspection by laminectomy, and then an



a *b*

Fig. 462.—Spinal hemorrhage: *a*, Extradural, or hematorachis; *b*, intradural, or hematomyelia.

associated hematomyelia is the condition for which the operation is usually performed. It requires considerable extradural pressure to affect the cord, and obviously a very severe injury would be required to produce bleeding enough to compress the cord outside its dural sheath; hence any such injury is almost invariably of the fracture-dislocation or allied type in which hematomyelia coexists and is the cause of symptoms. Practically speaking, the diagnosis of hematorachis is clinically impossible without laminectomy, but it can often be assumed to exist in injuries capable of causing hematomyelia.

Hematomyelia; Intradural Hemorrhage; Intramedullary Hemorrhage.—By this is meant hemorrhage occurring within the spinal cord coverings, affecting the cord substance itself.

There are two forms: (*a*) Primary focal hematomyelia, without bony injury, and (*b*) secondary hematomyelia, with bony injury.

The *pathology* in each form is practically the same, in that the anterior and posterior horns are the usual sites of involvement. The gray matter offers less resistance than the white to the spread of the blood, and hence the oozing is generally up and down rather than transversely. The area involved is usually asymmetric and the greatest area of bleeding is generally in the zone nearest the maximum of the trauma, the gray matter being mainly involved. In addition to the main areas of dissemination, smaller foci of punctate or minute hemorrhage may occur in the white matter.

The *extent* of the hemorrhage varies widely: in severe cases (so-called "spinal apoplexy") the cord may be almost wholly occupied by clot at the level of the hemorrhage.

The *effect* of the hemorrhage may be wholly mechanical and produce the damage solely by pressure; in other instances, inflammatory reaction occurs with subsequent degeneration.

After the bleeding is absorbed, cavities may remain resembling those seen in syringomyelia, and hence has arisen the term "traumatic syringomyelia."

(*a*) *Primary Focal Hematomyelia.*—There are but two locations in which this occurs, namely, the cervicodorsal, and very rarely in the lower lumbar region.

It is generally due to some forcible sudden temporary bending motion of the spine, either forward (flexion) or backward (extension), with an immediate springing back into place of the temporarily displaced vertebræ. Under these transitory conditions the exact cause of the bleeding is not known, but it is thought to be due to (1) a tearing of the blood-vessels incident to the stretching of the cord; (2) direct bruising of the vessels at the time the cord is temporarily impinged upon.

Whatever the cause, the main feature of this variety is the absence of any demonstrable change in the bony make-up of the spine and a rather prompt recession of symptoms.

Causes.—While the lesion is much rarer than fracture-dislocation, yet ordinarily the symptoms at first suggest bony injury.

Diving, falls on the head or neck, twisting or jamming of the head forward or backward, and allied forms of violence are the usual factors. By some, a temporary dislocation is supposed to always occur. Direct penetration of the cord, as by a bullet or weapon, is also causative.

Presumably the same *bending* and *penetrating* factors might cause

involvement in the lumbar region, but its occurrence here is a clinical rarity when unassociated with bony injury.

Symptoms.—These depend on the extent of the bleeding and its site; but, as stated, invasion is ordinarily of the horns of the gray matter and the parts immediately adjacent. The clinical picture is relatively constant and the essential elements are: (*a*) Motor paralysis which soon recedes; (*b*) sensory paralysis for pain or temperature (or both) and retention of sense of touch—the so-called "dissociation anesthesia."

Of course, with these signs of "internal injury," there may be objective evidences of "external injury" in the form of contusions, ecchymosis, wounds, swelling, local tenderness, pain on motion, rigidity, and other indications of local damage about the head, neck, and interscapular regions.

(*a*) *Motor paralysis* almost invariably occurs immediately on receipt of the injury, and in very few instances is there any "latent" or "free" interval.

As stated, the cervical region is most commonly affected, and for that reason the upper extremity becomes involved, chiefly the muscles of the hand and forearm, those of the upper arm being less often affected.

Inasmuch as the spinal nuclei of the brachial plexus is generally affected in this type, complete recovery is improbable, as some destructive damage usually occurs. This may involve but a single muscle eventually, but muscle groups at first generally suffer.

Hemorrhage great enough to affect the lower extremity may be and often is completely recovered from because the lesion is not destructive and the symptoms usually arise from edema and pressure on the pyramidal tracts. The earliest sign is flaccid paralysis, and this may involve all four extremities, or two, or be limited to one extremity, all depending upon the site and extent of the bleeding.

The lesion, if small, may cause no marked changes in the *reflexes*, or they may be exaggerated or lost. Later they become exaggerated, and in the lower extremity ankle clonus also appears.

Later the flaccidity gives way to rigidity, and when this spastic state appears the motion of the part begins to return. The lower extremity recovers before the upper, and even in marked cases power enough may return in a few weeks to permit walking. Atrophy to some extent is likely to remain in the arms, special muscles being selected, while those adjacent are apparently normal or nearly so in tone and action.

In the cervical cases *pupillary signs* are constantly present because of the involvement of the ciliospinal centers, and bilateral contraction of the pupil is present when the lesion is transverse; in unilateral lesions the pupillary signs are on the side of the lesion.

(*b*) *Sensory paralysis* in typical cases is manifested by the retention of the sense of touch and loss of the sense of pain (analgesia), heat, and cold (thermo-anesthesia). With very extensive clots there may be loss of sense of touch also, but this is very exceptional. Distorted sensations, as of numbness, pins and needles, crawling, and actual attacks of shooting pain, may also occur. Many cases are wholly free of pain; in others motion or pressure over the region involved causes much suffering.

Visceral symptoms affecting the bladder and rectum may also occur and there may be retention or incontinence at first. Later, control is regained, and the rectum usually responds first. Improvement in the bladder and rectum may begin in a few days and is usually progressive.

General symptoms, such as priapism, cyanosis of extremities, and tympanites, may also occur, but these are atypical. Bed-sores practically never occur.

Brown-Séquard type is that in which there is a motor paralysis in one arm and leg, and loss of pain and temperature sense (dissociation anesthesia) in the other arm and leg. The analgesia is generally less marked than the anesthesia and is usually the first to be regained.

This form of anesthesia is rather common, and is typical of spinal cord hemorrhage.

Diagnosis.—The main differentiation is to be made as between hemorrhage alone and bony injury; in other words, are the intraspinal evidences of pressure due to blood, laceration, or bone?

Typical cases of hematomyelia are characterized by—

(1) The sudden onset of marked flaccid paralysis in four, two, or one of the limbs, with sensory changes in the paralyzed limbs of the above-named dissociation type.

(2) The symptoms begin to show recession in a few days, visceral control often returning first, and later spasticity replaces flaccidity.

(3) The intraspinal evidences are often more marked than the extraspinal, and objective bony lesions are generally lacking.

Any case in which progression occurs after the first week is generally one in which primary focal hematomyelia is but an element and not the sole initiating causative factor.

Hysteria is sometimes hard to differentiate, but in this condition the history and type of patient and the existence of other signs (stigmata notably) is of determining value. Of course, the two may coexist; here again the history and examination offer main reliance.

Progressive muscular atrophy could only be confounded in very exceptional instances, as in this the condition is one of progression over very many years, and not of recession within a short time after a disabling injury. The necessity of differentiating this disease arises most often after recovery from some injury alleged to be a "localized spinal hemorrhage," and from which the atrophic condition is said to have started. Main reliance is to be placed upon the duration and extent of the manifestations, notably upon the place of their beginning as related to the spinal lesion.

Ulnar and brachial palsies offer the greatest confusion, and the question of occupation and possible toxic influences (notably lead and arsenic) need careful consideration. It is to be recalled that sometimes the disease in question may have existed for years until some general examination brings it to view.

Treatment.—Associated injury and shock are suitably treated. *General measures* are of prime importance, and the transport of the patient must be made carefully so that added damage to the parts may not occur.

In the absence of a water- or air-bed, the mattress must be exceedingly soft and the sheets kept free of creases so that no pressure occurs. In old persons, or where respiratory embarrassment threatens, the head of the bed is elevated a foot or more. So far as possible the patient is turned often from side to side or held thus by props placed under the side of the mattress. Aseptic catheterization three times daily is enough at first, later twice a day is sufficient. Some surgeons advise allowing the bladder to empty itself by overflow, but I do not approve of this and regard it as unclean and unsafe. If the urine becomes cloudy or purulent, irrigation of the bladder with boric solution is valuable. This is rarely needed more than once daily. *Urotropin* in 5-grain doses every four hours should be a routine measure. Occasionally 10 grains of *benzoate of soda* may be added to this dose if urinary alkalinity pertains. The bowels are emptied by a laxative or enema daily or every other day. Tympanites is controlled by salol, massage of the colon, or turpentine stupes or enemata.

Local measures relate to the application of adhesive straps over any painful spots on the spine or perhaps the use of a light plaster-of-Paris jacket. No operative or intraspinal manipulation is indicated, and

the use of the aspirating needle for diagnostic or other purposes is strongly inadvisable.

Treatment later is along the line of encouraging tone to paralyzed muscles, and at this time gymnastics, massage, and electricity are of great importance, but obviously these should not be used until recession is well under way. I have found much benefit from the use of improvised elastic or metal springs ("health exercisers") attached to the foot or head of the bed in such a way that the patient may force the inactive limb to do some work against resistance. Isolated paralyses are treated by special motions to re-educate their diminished or abolished functions. Tendon transplantation may bring surgical relief when all else fails.

Strychnin at this stage is very valuable.

Results.—Cases that begin to show improvement within the first week generally recover sufficiently to use the lower extremities, and often the upper extremities, to a greater or lesser degree. Visceral return in recoverable cases is usually prompt and lasting. Atrophy and loss of power in isolated muscles of the upper extremity usually persist in marked cases and sensory changes also pertain to some degree in these same areas.

The earlier the improvement the better the outlook.

SPINAL CONCUSSION

Some forty years ago this term was proposed and for a time had a vogue, but at present this diagnosis is nearly obsolete because of better knowledge as to the underlying causes of symptoms formerly designated by this title, and also because the term "concussion" is a misnomer as applied to the spinal contents, inasmuch as we now know they cannot be "concussed" in the same sense that "concussion of the brain" occurs.

The condition was at one time supposed to occur chiefly as an incident of railway collisions in which "the spine was jarred," and hence the term "railway spine" came into a sort of surgical usage, chiefly, however, in litigated cases.

There never was any adequate clinical or pathologic basis for this verbal entity, as most of the cases were in reality either sprains of the spinal ligaments or hematomyelia.

Erichsen in 1871 and again in 1875 sponsored the term and originally reported some 52 cases, the analyses of which today would cause them to be classified in grades of severity extending from fracture-dislocations of the spine to hysteroneurasthenia. As stated, surgical

nomenclature no longer lists the term, and it survives only as a memory among informed physicians, and even the laity, legal or otherwise, are forgetting it.

Quite recently the expression was used in court, and the unimpressed judge stripped it of any seriousness by asking the physician-witness, "What is the difference between a 'railroad spine' and a 'steamboat spine'?"

There is no form of physical or psychic trauma typical of railway accidents, inasmuch as the same injuries and nervous manifestations may arise from a great variety of other causes, all of which may be grouped under the term of "industrial accidents."

As Bailey has well stated, "there is no logical basis for the term 'spinal concussion' from the standpoint of etiology, symptomatology, or pathology. Cases having objective symptoms of spinal injury are now otherwise classified, those presenting a more or less well-authenticated history of violence in the spinal region with subjective symptoms are classified usually as neuroses."

INJURIES OF THE SPINAL CORD

Traumata of the cord itself are in the nature of contusions and lacerations.

Contusions of the Cord

A cord is said to be contused when it has been bruised, dented, or otherwise impinged upon without accompanying laceration of fibers.

Causes.—Sharp bending of the spine (either forward or backward), heavy blows over the spinous processes, and the already enumerated factors capable of producing fracture-dislocation.

It occurs most commonly in the cervicodorsal and dorsolumbar regions.

Symptoms.—Practically the signs of hematomyelia exist, with the external evidences of bony injury added. These are the cases in which paralysis of varying degrees appears, with corresponding abolition of sensation, reflexes, and visceral control.

The site and extent of involvement determines the nature of the symptoms; but no definite statement can be made as to the amount of bruising until the coexisting hemorrhage subsides, and this usually takes a week. If, after this lapse, no improvement occurs, structural damage to the cord substance may be presumed, either in the nature of simple bruising or laceration, or both. If temperature is present and there are no septic foci to account for it, a myelitis may be assumed to exist.

Persistence of symptoms after temporary recession may indicate localized edema, cyst formation, or localized serous meningitis.

Treatment.—A waiting policy is advisable if pressure from bone can be excluded and if there is doubt as to the presence of blood-clot. After a week or so, in the presence of ascending symptoms, laminectomy is advisable so that decompression may avert degeneration from any edema, cystic formation, or myelitis.

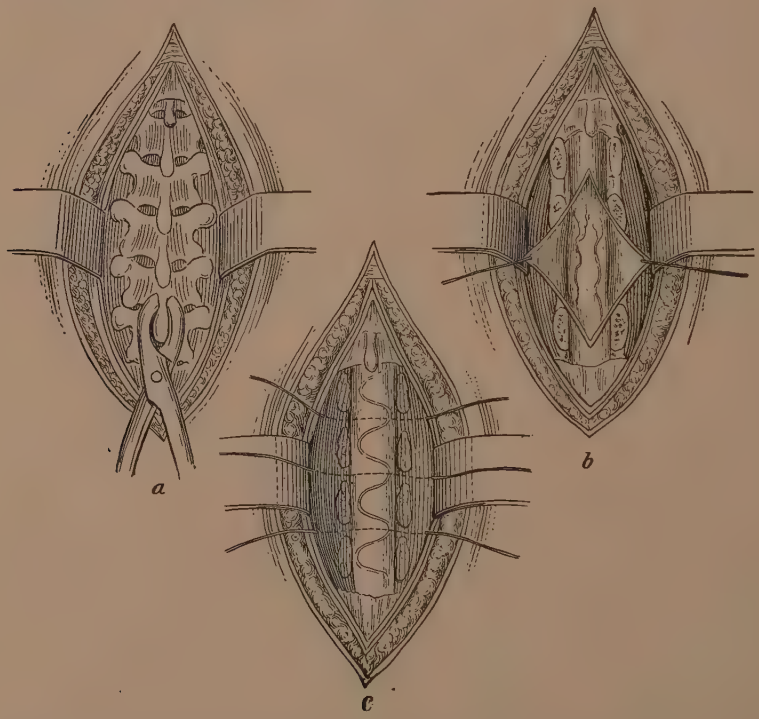


Fig. 463.—Laminectomy: *a*, Removal of spinous processes and laminæ; *b*, dura slit and retracted by sutures; *c*, dura sutured by running stitch; three retention sutures passed through muscle, fascia, and skin.

Hemilaminectomy may suffice in some cases, but the procedure affording the quickest, most adequate access in my experience is the following:

Patient wholly prone or partially so with pillows under one shoulder and edge of chest and abdomen; ether anesthesia or mixed anesthesia intranasally. Tincture of iodin applied to the dry back in the operative field. Incision 6 to 8 inches long just lateral to the ridges of the spinous processes, this reaching to the depth of bone beneath. Retract the muscles outward and clear the arches by periosteal elevator. Pack this wound with gauze pads wrung out in hot saline solution.

Clear the opposite half of the arch in the same way and similarly pack the wound thus made. The bleeding is generally excessive, but this sort of pressure eventually will give a dry field. With a rongeur gnaw away an available spinous process down to its base and then remove the latter with a smaller beaked tongue rongeur, and thus the spinal meninges are brought into view. Repeat this process along the laminæ until the cord is exposed to the extent desired (Fig. 463). Normally it should be pulsating and pearly gray, but it may be quite dusky and pulseless. A bent probe or director may be inserted up and down the canal in a search for bony obstruction or clot. A ridge, mottling, or change of contour may denote the site of greatest damage and the dura may or may not be intact. Cerebrospinal fluid may appear at once or gush out during the manipulation, as if under tension or confined.

It is generally advisable to open the dura, and it is accordingly caught at each margin by mouse-tooth forceps (as in opening the peritoneum), nicked, and the incision is then extended by small scissors to the desired extent. The edges of the dura may be held apart by stitches placed on either side, and these are then held by clamps at the edge of the wound.

Clots may be found or damage may be evident by indentation, flattening, or even pulpification. If the cord is edematous, it has been advised to make small vertical incisions upon or punctures of it in many spots with a needle. Personally I have never done this and know nothing of the efficacy or wisdom of it, and prefer to rely upon the decompression afforded by the other steps of the operation.

The dura is carefully closed by fine silk or catgut, *and this closure must never be omitted even in the presence of oozing cord substance.* The muscles are sutured by catgut or kangaroo tendon and a separate layer of sutures coapts the fascia. The skin is closed by silk or silkworm-gut *and no absorbable suture must be used therein,* as it frequently breaks and thus allows the wound to gape on the tenth day or later. A few retention stitches tied over a roll of gauze or rubber tubing act especially well in long wounds.

Drainage should not be used. If for any reason it is employed, folded rubber tissue or a few strands of twisted catgut or silkworm-gut are introduced down to the level of the sutured dura, but under no condition should it go deeper. All possible blood should be squeezed from the wound and a heavy gauze and cotton dressing applied with adhesive straps snugly covering all. There is no need of a plaster-of-Paris jacket unless redislocation or aggravation of bony deformity is feared. The dressing is changed on the tenth day unless

there is indication for earlier removal of it. The stitches are removed then and a gauze and adhesive plaster dressing reapplied.

Results.—Practically those of hematomyelia or laceration of the cord.

Laceration of the Cord

This sort of damage varies in extent, but for practical purposes may be grouped as (*a*) slight; (*b*) moderate; (*c*) severe (crushing, pulpification, severing).

Causes.—Ordinarily the factors producing fracture-dislocation are at fault, as bony injury almost always coexists. This type of damage hence represents the severer forms of spinal violence, such as crushing, sharp bending, and heavy blows in a stooping posture. Another group depends upon actual penetration, usually from stab wounds and the presence of foreign bodies (as bullets).

(*a*) **Slight Lacerations.**—The dura may or may not be torn and the extent of the damage is limited to a portion of a vertical or transverse segment. The posterior portion of the dorsolumbar cord is generally the part affected, and in no instance of this group is more than one-fourth of the cord diameter involved.

Symptoms.—Differentiation from localized spinal hemorrhage or bony pressure cannot be made unless the history, lapse of time, radiographs, or operations give corroborative evidence.

Any localized motor and sensory paralysis persisting more than a week without improvement justifies this presumptive diagnosis, assuming that the violence and the history are adequate. The most typical cases are those in which a bullet or missile has cut or nicked a well-defined margin of the cord, or localized bony spiculæ impinge, and in such instances the symptoms are more easily determinable.

(*b*) **Moderate Lacerations.**—These are cases in which the motor, sensory, reflex, trophic, and visceral involvement is of such a grade that cord function is abolished at and below the level of the lesion. Usually extensive penetration or fracture-dislocation exists, and ordinarily the damage is unequally bilateral.

This is the type common to most of the severe spinal injuries and the paralysis (usually of the lower extremities) is immediate, showing little or no recession, but on the contrary often progressing. The dura is generally involved. Cases of this sort promptly develop bed-sores unless great care is given, and the bowel and bladder function is wholly abolished.

Many of these patients die within the first few days of (1) shock; (2) associate injuries; (3) pneumonia; (4) delirium tremens, or (5)

failing kidneys. Those surviving the first week may live from three to six months and then die of sepsis from ascending urinary infection or bed-sores. Some few apparently succumb to a progressing myelitis and general malnutrition.

In my experience very few patients surviving the first week die from spinal injury *per se*, the majority of deaths being due to sepsis and pneumonia. The mortality in operated cases will later be stated.

(*c*) **Severe Lacerations.**—These are the cases of so-called "complete crushing," "severing of the cord," or "pulpification of the cord." They represent the maximum of intraspinal injury, and fracture-dislocation or gross penetrations are practically the sole causes. Not only are the spinal arches often broken, but the vertebral bodies as well, and there is always dislocation or impingement enough to produce distinct angulation of the compressed and much damaged cord. The meninges generally are torn, and through the rent cord substance may extrude. If the dura is untorn, opening of it at operation or autopsy discloses pulpification and often the gray matter is found disintegrated. The cord is very rarely completely severed, but often it is held together by very few strands laterally and it is virtually amputated.

In the absence of direct inspection it is impossible to clinically differentiate this form and the preceding.

The lease of life in unoperated cases is similar to the preceding, and the outlook is exceedingly grave even with prompt recognition and early operation. Most cases die, and those that live are more or less bed-ridden.

General Diagnosis of Cord Laceration.—*The degree of laceration cannot be estimated accurately except by operative inspection.* Assuming a history of injury to the spine of a crushing or bending type associated with immediate motor-sensory paralysis, abolition of reflexes, lost bowel and bladder control, the physician will be early called upon to determine the following: (1) Is there bony injury? (2) Is the cord lacerated? (3) Is operation indicated? (4) What is the probable outcome as to life and restoration of function?

(1) *Is there bony injury?* Fracture-dislocation can be reliably presumed in the presence of bony deformity, localized ecchymosis, tenderness, false motion, and crepitus.

In the *cervical region*, bony injury is more likely to be dislocation alone, and then reliance is placed on the attitude of the head and upper extremities and the visible malalignment of the spinous processes of the neck, and of the cervical bodies palpable through the pharynx.

x-Ray examination is exceedingly helpful, but with extensive paralysis it generally is but corroborative.

(2) *Is the cord lacerated?* If there is recession of motor-sensory paralysis within the first two days, the cord is probably damaged to some extent. Stationary or progressive symptoms after the first week render this opinion stronger, especially in the presence of fracture-dislocation or demonstrable penetration by a bullet or cutting instrument. As stated, the degree of laceration cannot be adequately determined until the cord is exposed, and a presumptive diagnosis is often wholly found wrong at operation or autopsy. The extent of the cord damage is inferentially greatest when bony injury is greatest, but, fortunately, this rule is not absolute. The converse is unfortunately equally true, as an apparently moderate degree of bony injury does not by any means denote moderate cord laceration.

(3) *Is operation indicated?* This depends upon several main factors, of which may be mentioned: (*a*) General condition of the patient as to physique, age, occupation, and associated injuries. (*b*) Extent of apparent cord damage. (*c*) Operative facilities.

(*a*) *General condition of patient* is the main element and no operative relief should be offered unless the physique is adequate. The aged and alcoholics are the poorest surgical risks; young healthy adults offer the best prospects. Manifestly, shock and coincident injuries are often contra-indications. Bed-sores or other infective zones near the operative field offer great hazards.

Generally speaking, it is better to wait a few days before undertaking laminectomy even in recognizable cases (penetrations excepted).

(*b*) *Extent of Damage.*—Personally, it is my opinion that *every case of laceration will not be harmed by laminectomy*. Many of them I am aware apparently recover without operation; but it is well to remember that in these so-called "lacerations" the diagnosis was at best inferential and dependent very largely upon the belief that marked bony angulation of necessity predicates some degree of cord laceration. That viewpoint does not appear to be at all conclusive.

No case is too extensive to be given an operative chance, as most cases of this severe type are doomed without it at all events; *per se*, the operation does not add great hazards, and in the average case it requires about forty minutes for completion. Minor degrees of lacerations are often much benefited by operation, as the decompression prevents localized serous meningitis (hydromyelia), edema, cyst formation, and organization of clots.

The removal of many spinous processes does not in any way

imperil the bony framework, as the main support is imposed upon and derived from the vertebral bodies. After laminectomy the gap left by the removal of the arches becomes filled by a cartilaginous mass, and in some cases a new bony arch is said to form (Cushing).

(*c*) *Operative Facilities.*—Asepsis is an essential to success and the surgeon should have experience in this class of spinal work before undertaking it.

In a general way it may be stated that operation is the treatment of choice in those cases of intraspinal injury in which improvement does not begin within the first week. The earlier the operation, the better the outlook, but even after the lapse of years improvement has occurred in cords released from bony pressure and the angulation due to distortion of the spinal column.

(4) *What is the probable outcome as to life and function?* Early fatalities occur within the first few days, and cases that live a week generally die from septic complications and not from the injury *per se;* hence the prognosis becomes one of maintaining asepsis. Septic cases die within the first six months as a rule. Patients living a year enter the chronic invalid class and die of intercurrent affections more or less dissociated from the initial injury. Functional return depends largely upon the initial extent of injury and the treatment. Operated cases do better than those unoperated, and even if the outcome is unfavorable the patient and the physician have the assurance that every effort was made to relieve demonstrable pressure and restore the cord more or less to the normal.

Mild degrees of laceration may go on to complete restoration of function, but the *moderate* and *severe grades* usually result in permanent loss of function of varying degrees.

Regeneration of the cord after lacerations is held by many to be anatomically and physiologically impossible because there is no neurilemma; but despite this, there is abundant clinical proof that restoration does occur, to some degrees at least, even in a cord completely torn across. Stewart and Harte's case is an instance of proved regeneration after deliberate suturing of the severed ends of an injured cord. Fowler's case is another, and that of Haynes (bullet wound of liver and cord) falls into the same grouping, although the degree of laceration was less. This last named case is personally known to me because I sutured the wound in the liver and subsequently had the opportunity of assisting Dr. Irving S. Haynes at the laminectomy and cord suturing. Later this girl was presented at the Academy of Medicine and she was then able to walk, and at the present writing is

earning her living as a housemaid. She was totally paraplegic from a .32-caliber bullet wound penetrating the right upper abdomen and liver, entering the spine at the lower dorsal levels traversing an intervertebral disk. The cord was perforated almost at the center but there remained some intact fibers laterally.

This case and others are reported in detail in the literature.

The reasons for recovery after destruction of cord substance are not well determined, but apparently rest upon a combination of the following factors:

(*a*) Bridging of the gap by new formed nerve or connective tissue that in time conveys proper impulses.

(*b*) Vicarious action on the part of adjacent undamaged segments.

(*c*) Organization of blood-clot and later penetration of it by nerve-fibers.

(*d*) Nerve-root spontaneous anastomosis.

Suggestive literature as to this is mentioned in editorial comment of the *Jour. Amer. Med. Assoc.*, February 27, 1915, p. 746.

Whatever the reason, I am firmly of the opinion *that some sort of recovery* is possible if we can keep the patient alive long enough.

In this connection, I had under my care about three years ago a heavily built man (aged forty-eight) who had been caught between a moving elevator and the floor in such a way as to sustain a fracture-dislocation in the dorsolumbar region, with fractures of several ribs in addition. He had complete motor-sensory paralysis downward approximately from the level of the umbilicus, with abolition of the function of the bowels and bladder also.

Numerous radiograms were made and in about ten days conditions allowed us to perform laminectomy, at which the writer had the valued association of Dr. Irving S. Haynes, in whose Harlem Hospital service the patient had been admitted. The cord was found to be pulpified and portions of it extruded and escaped when the dura was opened. Despite this the membranes were sutured and the soft parts were closed except for a small submuscular drain. Primary union was obtained and the first notable effect was healing of the bed-sores which had appeared on the buttocks and heels. Later the patient was removed to the Red Cross Hospital and active massage and electric treatment were given for several months. Subsequently various gymnastic motions were practised, and the patient was soon able to propel himself in a wheeled chair, and has now learned to get about in an invalid walker. He has a certain amount of sensory return, with a remarkable visible and palpable increase in the musculature of the lower extremi-

ties, together with a reappearance of knee-jerks and ankle clonus. He has a certain sensation when his bowels are about to empty and his bladder empties by spontaneous overflow. My belief is that further improvement will occur despite a very high grade of cord injury that apparently indicated an early fatality.

CORD INFLAMMATION

Involvement of the coverings (**meningitis**) never occurs in the absence of infection, and hence trauma is only responsible when penetration from without has occurred. It is exceedingly rare unassociated with involvement of the cord substance itself, and thus the diagnosis of **myelitis** or **meningomyelitis** is usually made.

I have never known of a case of "traumatic spinal meningitis" that was not in reality an example of "traumatic myelitis," and no case has come to my notice in which minor grades of injury (falls, blows, twists) were causative. It is exceedingly common to have a history given of some more or less recent injury to the back or spine, but practically all of these are coincidental and in nowise causative. It will be recalled that a similar history is usually volunteered or obtained in cerebrospinal meningitis also, but in each instance the relationship is not much closer than a history of a preceding blow on the abdomen would be to a later developing typhoid.

Myelitis is inflammation of the cord substance, and it occurs as a complication of many intraspinal injuries associated with contusion and laceration of the cord.

Fracture-dislocation and penetrating wounds (bullets and stabs) are the common causes. Hematomyelia is an exceedingly rare origin.

The condition has been previously described in connection with fracture-dislocation and contusions and lacerations of the cord.

It does not occur from ordinary injury to the back or spine, and in the absence of a considerable injuring force is usually part of a cerebrospinal inflammation of germ origin.

It is to be remembered that there are numerous causes of cord inflammation independent of injury, and these may induce sudden onset of paralysis ("acute myelitis") or cause symptoms to appear gradually ("chronic myelitis").

FRACTURE DISLOCATION OF THE SPINE

As previously stated, dislocation without fracture is exceedingly rare, but the reverse is not uncommon.

Dislocations have already been spoken of (see pages 191–201).

Frequency and Varieties.—This is a relatively rare form of injury, and in my list there were 22 cases in the list of 5008 fractures, a percentage of .44. The cervical and dorsal regions are about equally often involved; lumbar involvement is about one-half as frequent as either of the two preceding. Cervical types are far more commonly fatal, and above the level of the fourth cervical, death is usually prompt. The fifth and sixth cervical, the twelfth (last) dorsal, and the first lumbar vertebræ are more often broken than all the others.

Clinically speaking, most spinal injuries occur in the cervicodorsal or dorsolumbar regions.

The *bodies* of the vertebræ are broken in about two-thirds of all the cases, and the fracturing line may be vertical or transverse or more or less asymmetric, and in one or more planes. Crushing of the vertebral body is not uncommon, and it is broken in over one-half the cervical, seven-eighths of dorsal, and practically all lumbar fractures. In the cervical and upper dorsal region simultaneous fracture of two or more vertebræ is the rule; but in the lower dorsal and especially in the lumbar sections a single vertebra is generally affected.

The *arches* are usually involved to some extent with the *bodies*, the rule being to have involvement of the *arch* corresponding or adjacent to the fractured *body*, the *transverse processes*, *pedicles*, and *laminæ* being the parts usually affected. The *arches* are affected in about one-half the cervical and in one-eighth of dorsal and lumbar fractures.

Fracture of the *spinous processes* in association with other fractures of the vertebra occurs in about one-half the cervical cases.

Dislocation may be absent in fractures of the cervical region, but is practically always present in other regions. The extent of the displacement varies, depending upon the manner of the injury, but ordinarily the upper vertebra is displaced forward so that it may distort, contuse, or lacerate the cord. There may be also more or less rotation or lateral displacement of the bodies; either of these deformations tend to malalign the spinal column and narrow the spinal canal and thus interfere with cord function.

The *intervertebral ligaments* and *disks* are commensurately affected, and the latter may even be crushed or squeezed out of position.

Causes.—*Muscular violence* is the rarest element and is responsible only in the cervical regions as a rule. Sudden twists or jerks of the head may fracture the arches and exceptionally produce fracture-dislocation. Diving accidents occasionally are partially due to efforts

to avoid striking the bottom by pulling the head backward, with the additional damage following direct contact.

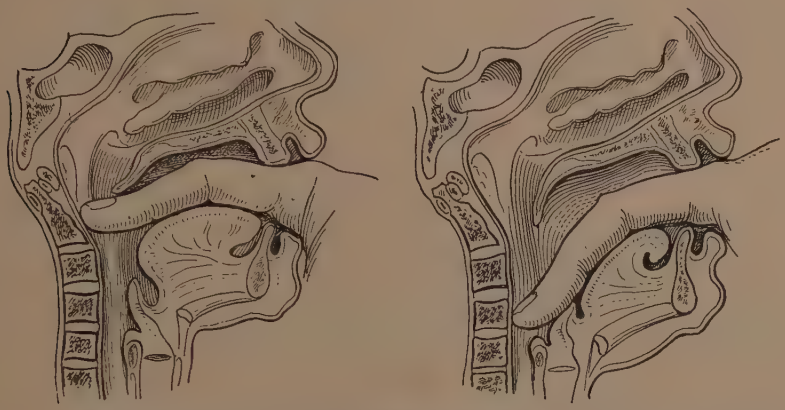


Fig. 464.—Range of digital pharyngeal palpation of cervical vertebra in fracture or dislocation.

Direct violence from heavy blows on the neck or back, forcible crushing, and allied forms of violence generally damage the *arches* and may produce intraspinal involvement from hemorrhage or impinging of a bony fragment.

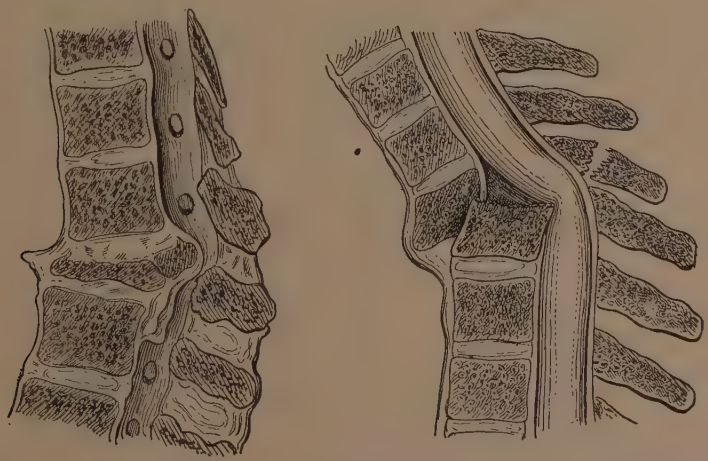


Fig. 465.—Fracture-dislocation of the spine with impingement of the spinal cord.

Indirect violence is the usual factor, such as from sudden severe forward bendings, twists, and archings of the spine from a variety of causes. Of these may be mentioned falls, heavy blows while in a bent or crouching position, jamming in narrow spaces, and in fact any severe

motions tending to cause the spine to suddenly assume a "jack-knife" attitude. Aboard ship many cases arise from falls from rigging or into holds; railway cases are generally from falls and coupling cars; mine accidents from cave-ins; in building operations from blows of falling material or jamming forces; diving and football are the common causes among the sports; trapeze and acrobatic stunts furnish another group.

Slight degrees of violence do not produce fracture-dislocation, and the grade of needed violence is greatest in the lower portions of the

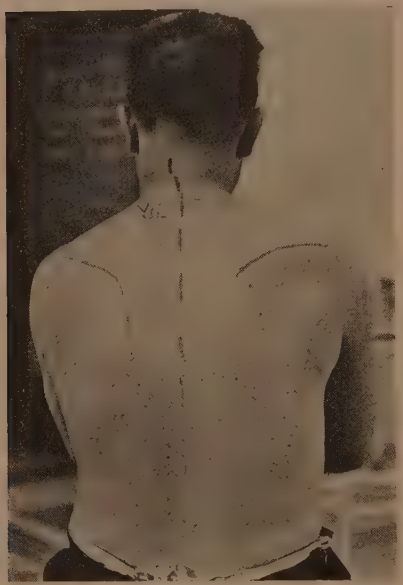


Fig. 466.—Fracture of sixth cervical vertebra; note deformity, the markings indicating spinous processes.

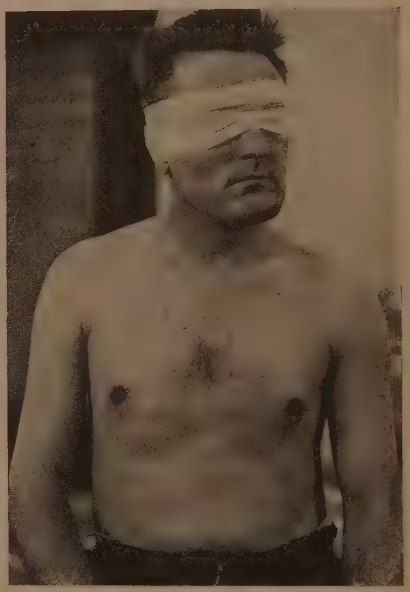


Fig. 467.—Fracture of sixth cervical vertebra; note postural deformity. Patient hurt eighteen months previously while diving. No symptoms now aside from stiffness of neck, postural deformity, and numbness and trophic disturbances of left upper extremity.

spinal column where the parts are strongest and least flexible (Figs. 464, 465).

Symptoms.—*Cervical Region.*—Between 25 and 35 per cent. of spinal lesions affect this level.

Atlas and *axis involvement* are clinical curiosities, as death is nearly always instantaneous; accurate classification of these cases, after a provisional diagnosis of "broken neck" or "fractured base of skull," is usually made by the pathologist.

Midcervical involvement also results in prompt death on account of

diaphragmatic paralysis from phrenic nerve invasion as it passes out between the third and fourth vertebræ. Pupillary signs may also exist.

Lower cervical involvement includes those below the fourth vertebra, and the typical symptoms relate chiefly to involvement of the brachial plexus (composed of the fifth, sixth, seventh, and eighth cervical and first dorsal nerves).

The phrenic nerve may here also be involved at the time of the accident, or become so later, and thus result in the sudden death occurring so often in this type of injury (Figs. 466–468).

Fig. 468.—Fracture of sixth cervical vertebra.

Obviously, the extent of injury will determine the symptoms and in part the outcome, and thus all grades of manifestations are met with. *Local signs* may show by an altered position of the head (flexed, rotated, extended); swelling or external evidence of malalignment over the region of the spinous processes (Fig. 469); local ecchymosis; rigidity or spasm of the neck muscles; pain on motion of the head and upper extremities. Crepitus and false motion may be present.

The deformity typical of some cervical lesions is shown in the diagrams.

Neural signs are those of motor flaccid paralysis at the level of

and below the lesion, this usually being complete or nearly so. Respiration is generally affected to some degree, especially expiration. In some cases the paralysis may not reach higher than the middle of the body at first, but within a few days it reaches the height of the lesion. There may be considerable asymmetry so that one arm is more involved than the other. The paralysis of the lower limbs is spastic in invasions of this region. Priapism occurs oftener in cervical involvement than in any other segment.

Fig. 469.—Dorsal vertebræ, lateral view.

Sensory signs correspond to but are lower than that of muscle loss, and generally anesthesia extends as high as the nipples; in the arms there may be various root pains with paresthetic feelings, and it is not uncommon for the level of anesthesia to rise after the first day, but it rarely reaches as high as the lesion.

Muscle spasms occasionally occur. Dissociation anesthesia is pathognomonic of hematomyelia and thus rarely occurs in typical fracture-dislocation.

Visceral and *trophic signs* are generally complete in marked cases.

Upper dorsal involvement is usually regarded as including the upper ten bones of this segment.

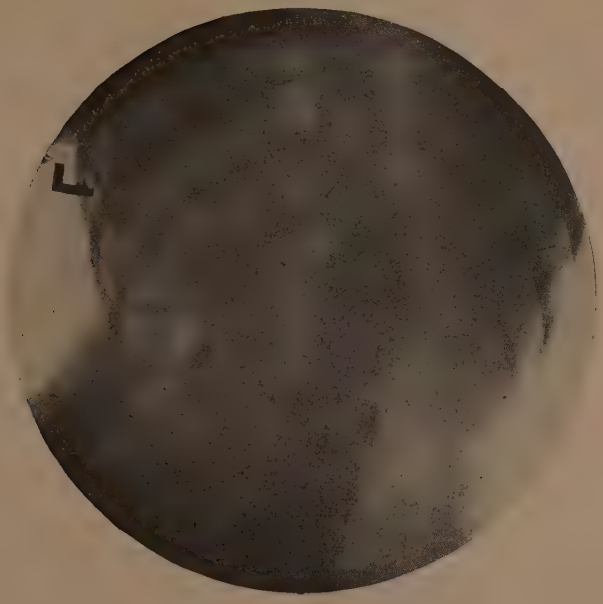


Fig. 470.

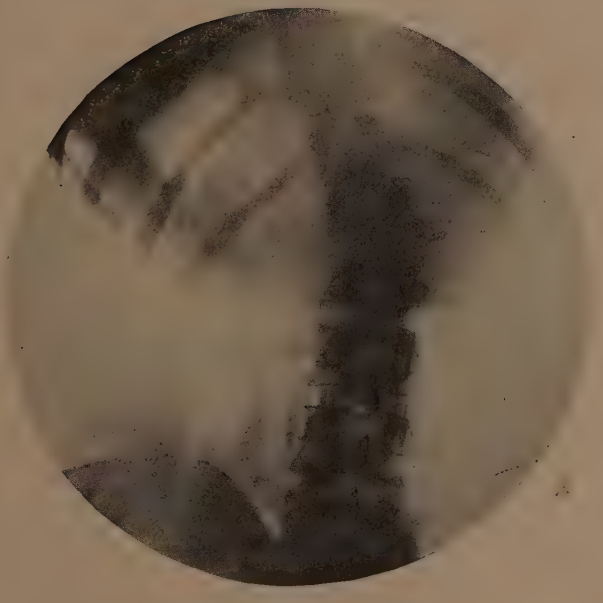


Fig. 471.

Figs. 470, 471.—Fracture-dislocation of the (I–II) lumbar vertebræ in a patient showing marked old spinal curvature. There were no intraspinal symptoms in this case. This patient also broke her leg in the same accident (see Fig. 401).

Fig. 472.—Fracture-dislocation of the first and second lumbar vertebræ.

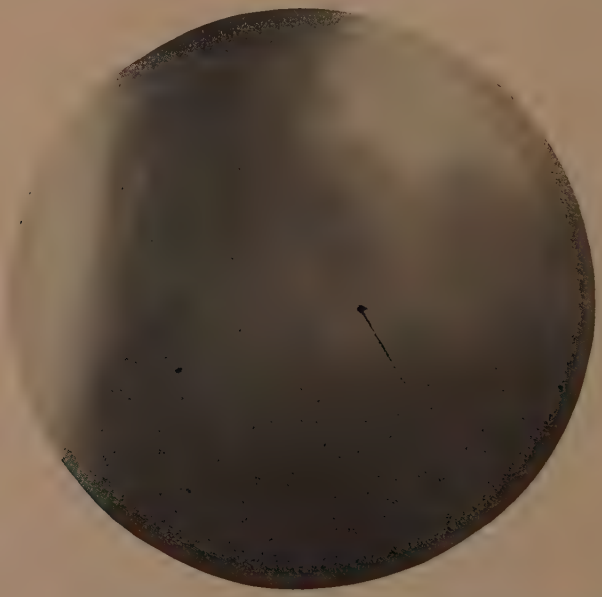


Fig. 473.—Fracture-dislocation of the dorsal vertebræ; note the fracture of the body of the vertebra.

Local signs include visible deformity (usually kyphosis) over the spinous processes involved, perhaps with regional swelling, ecchymosis, and malalignment. Local tenderness, rigidity, or spasm of

muscle may be present; crepitus and false motion are occasional. Sometimes a palpable gap marks the site of trouble.

Neural signs are indicated by paralysis of motion at and below the level of the lesion; all grades are present depending upon the amount of cord damage.

Sensory signs are indicated by anesthesia corresponding usually to the motor loss, with an area of hyperesthesia just about the level of the lesion; this *hyperesthetic zone* is the best single index of the height of the damage in any case.

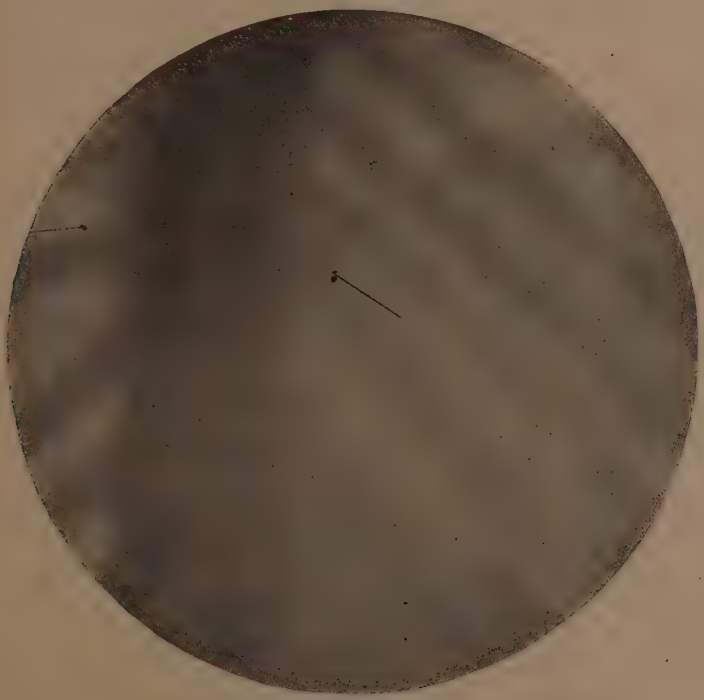


Fig. 474.—Fracture of the transverse processes of a dorsal vertebra.

Visceral and *trophic signs* are generally present, and the rectum and bladder are nearly always involved, even if the lesion is incomplete and at first apparently insignificant (Figs. 470–475).

Lower two dorsal and *upper two lumbar involvements* are very common and the term "dorsolumbar" is given to this group; over one-half the cases are in this zone.

Local signs are similar to the preceding.

Neural signs are manifested by motor paralysis (complete or incomplete) at and below the level of the lesion; the extent of paralysis may take some hours to become fully manifest.

Sensory signs may not appear at once, but when present correspond to the motor distribution. Anesthesia is generally in the form of an irregular girdle that may reach as high as the umbilicus; or more often to the level of the superior iliac spines.

Visceral and *trophic signs* often are late in onset, but usually coexist.

Lower three lumbar involvements (Fig. 476) often give few signs of a strictly neural sort because the cord ends at the lower part of the second lumbar vertebra, and thereafter the conus medullaris and cauda equina only can be impinged upon.

Fig. 475.—Fracture of sacrum.

Local signs are few and asymmetry is unusual, and evidences of bony invasion are with difficulty determined in the absence of *x*-ray examination.

Motor signs may be present as an affection of the muscles of locomotion, but both limbs are rarely affected alike.

Sensory signs are generally in the form of more or less saddle-shaped anesthetic areas in the peri-anal, gluteal, or perineal regions.

Visceral and *trophic signs* may or may not exist.

Behavior of the reflexes in all forms depends on the level of the lesion.

That of the *knee* is absent or diminished in lesions of the second, third, and fourth lumbar segments; above this level they are absent at once, below they may be intact. Loss of the knee-jerks is not of itself an index of complete laceration of the cord, as it may persist even in total severance. The earlier it returns, the better the outlook, and when exaggerated the cord damage is incomplete.

Ankle-clonus and exaggerated knee-jerks usually coexist.

The *plantar reflex* is absent in lesions of the upper three sacral segments; above this level the *Babinski reflex* is also present.

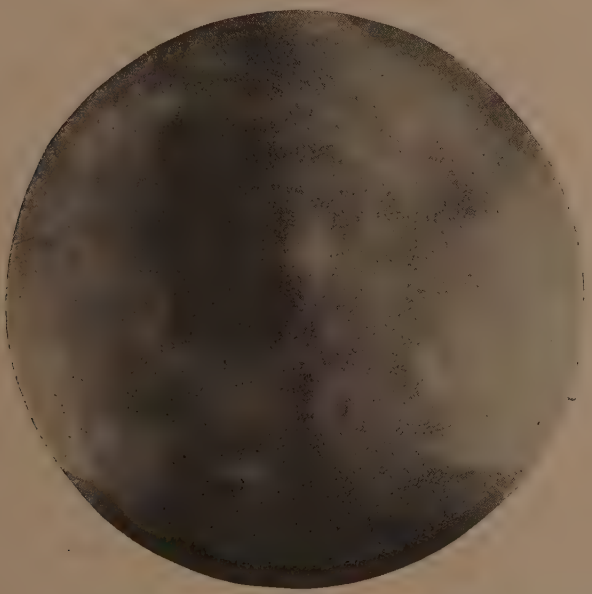


Fig. 476.—Fracture-dislocation of the second and third lumbar vertebræ.

Superficial reflexes are unreliable, but are generally lost in complete lesions.

Variation in symptoms ordinarily occurs within the first three or four days.

Retrogression is a good indication that part of the damage, at least, is from hematomyelia.

Accession is an unfavorable sign indicative of myelitis, especially if fever exists.

Diagnostic Factors.—About one-quarter of all cases are in the cervicodorsal and about one-half in the dorsolumbar region. Above the fourth cervical most cases are rapidly fatal, and the prognosis becomes increasingly better from this level downward.

Bony involvement is determinable by the ordinary fracture-dislocation signs, such as:

(1) *Deformity:* Spinous process malalignment, swelling, posture.

(2) *Discoloration:* Bruising, ecchymosis.

(3) *Palpation:* Local pain, rigidity, spasm of muscles, crepitus, false motion, interspinous grooving, or irregularity.

(4) *x-Ray examination:* Postero-anterior and lateral views should be made when possible.

Care must be exercised in excluding an old deformity, such as kyphosis or lordosis.

Cord involvement is determined by: (1) *Motor paralysis:* Partial or complete, asymmetric or symmetric. Extensors usually more involved than flexors, and all grades are encountered, from weakness to abject flaccidity. Spasticity after flaccidity is common.

The "motor level" is generally that of the lesion, but may be below it; if above it, myelitis probably exists.

Recession is a sign of hemorrhage and of good import.

(2) *Sensory Paralysis.*—Rarely symmetric or complete, and usually some distance below the zone affected, because the sensory nerves run downward some distance before leaving the spinal canal. According to "Sherrington's law" each zone or area of the skin is supplied by three spinal roots (tactile, pain, thermal, muscular) and anesthesia only occurs when three successive roots are involved.

Thermosensory loss with preservation of pain and touch is pathognomonic of hematomyelia.

The "hyperesthetic zone" above the anesthetic zone is the best single index of the level of the lesion.

Paresthetic and root pains are good omens indicative of incomplete involvement or returning sensation.

(3) *Visceral Paralysis.*—Rectum and bladder are involved together and are affected in any considerable lesion; in recovering cases, rectal power is usually first regained. In true paralysis of the rectum the finger is not contracted upon when introduced within the anus.

(4) *Trophic Paralysis.*—Edema, duskiness, dryness, scaling, and cracking of the skin often precede the formation of bed-sores that predilect the sacral, gluteal, malleolar, and heel regions.

They occur in lesions at all levels and atrophy and contractures often coexist.

How much is the cord involved? (1) The *extent of bony involvement* is no certain index, because the damage may be done by a knuckling

of the spine before it sprang back into a normal or nearly normal position.

(2) *Extent of paralysis* is the best evidence, and the most serious cases show at and below the lesion: (*a*) Immediate, total, persistent flaccid motor paralysis. (*b*) Immediate, total, persistent sensory paralysis. (*c*) Immediate, total, persistent visceral paralysis. (*d*) Immediate, total, persistent loss of reflexes.

Variations in totality and persistency from the above usually indicate that complete laceration of the cord has not occurred.

A reasonably certain opinion often cannot be expressed within the first four days, as during that period symptoms are apt to increase or decrease; a better prognostication can be made after the lapse of a month.

It is to be remembered that there is but one certain method of determining the exact conditions, namely, by actual laminectomy inspection. Many cases of apparent complete severance are thus proved to be not as severe as anticipated; and, conversely, cases apparently of partial severance prove to be actual pulpification of the gray matter with more or less intact surroundings.

Prognosis in General.—This depends upon: (*a*) Site and extent of the lesion; (*b*) the individual; (*c*) the treatment.

(*a*) *Site and extent of the lesion* is the most important.

Above the fourth cervical level, practically all cases die at once, or within a short period, from respiratory failure. Many of them expire suddenly from acute pressure during transport or treatment.

The general mortality ranges between 65 per cent. (Burell's 244 collected cases) and 80 per cent. (Gurlt's 270 collected cases). According to Burell, there is a mortality of 85.7 per cent. in the cervical; 76.7 per cent. in the upper dorsal; 56.1 per cent. in the lower dorsal; and 50 per cent. on the lumbar regions.

Return of function may be better in the cervical than in the other regions because the grade of injury is often less severe and associated injuries are less likely to occur. The lower the lesion, the better the prognosis as to life, but not necessarily as to function. Obviously, the greatest mortality and disability follows the severe injuries to the cord irrespective of the nature of the injury to the column. Severe cases die within the first week of shock, associated injuries, pneumonia, anuria, or delirium tremens; cases surviving this period may live six months unless death occurs from sepsis (bladder or bed-sores) or hypostatic changes. Beyond this half year life may be prolonged a year or more if sepsis can be prevented, and then death may

come from any of the intercurrent ills to which chronic invalids are subjected.

In the first week fatality is generally due to the trauma itself, but thereafter it is due to complications, of which sepsis is the chief. Burell states that of his recorded 35.5 per cent. of recoveries, 62.2 per cent. were functionally useful, 37.8 per cent. were useless (Keen's *Surgery*). Statistics are obviously very misleading, as in many the exact diagnosis is unknown, the associated injuries of themselves may have been fatal, and treatment and nursing may or may not have been adequate. It is admittedly true that the present day mortality is less than formerly.

Treatment.—

- (A) *General*
  - Transport
  - Bed
  - Bladder
  - Bowels
  - Skin and decubitus
- (B) *Local*
  - Non-operative
    - Apparatus
      - Braces
      - Plaster
    - Traction
      - Inclined planes
      - Suspension
    - Extension
  - Bone and cord
    - Operative
      - Laminectomy
      - Cord
        - Suture
        - Resection
  - Muscles: Electricity; vibration; massage; gymnastics; chairs; invalid walkers.

(*A*) *General Treatment.—Transport* should be as carefully made as possible, preferably with the patient lying flat on the back or face. Any forced bending or change of position is to be very carefully guarded against, notably any sudden motions of the spine.

Bed.—The mattress should be filled with air or water when possible, otherwise it should be extremely smooth and so arranged that pressure is kept off the sacrum, heels, knees, and malleoli.

Bladder should be emptied at least night and morning by catheter, and the asepsis must be perfect, and when possible one person should be assigned to this duty. The boiled catheter should be soft rubber for each sex and suitably lubricated with sterile oil, glycerin, or other emollient. The meatus is first sponged with a weak antiseptic solution (as bichlorid 1 : 10,000), and the attendant will feel more reasonably sure of his own cleanliness if sterile gloves (cotton or rubber) are worn. The urethra must be traversed very gently and force is decidedly harmful. Urotropin should be given every four hours in 5-grain doses for a month; thereafter it may be reduced in frequency if conditions permit. If the urine becomes alkaline, ammoniacal, foul, thick, muddy, or purulent, the bladder should be gently washed once or more daily with boric acid, salt, or weak permanganate solution.

In many cases the bladder may be trusted to spontaneously empty itself into a urinal constantly left between the patient's legs; but my personal preference is for catheterization for the first week at least, assuming that it can be done reliably. If this is impossible, then spontaneous urination is less dangerous than faulty catheterization. It has been stated that a suprapubic or perineal operative opening into the bladder would allow the best form of drainage, but this is rarely called for and has inherent dangers. The external parts must be kept very dry.

The aseptic control of the bladder is probably the most essential element in treatment.

Bowels are emptied daily by enema or a mild laxative, and by a process of training they may be made to respond at a set time usually. Tympanites is an annoying feature at times; aromatic spirits of ammonia or Hoffmann's anodyne (½ teaspoonful of either in ½ glass very hot water) will usually control it. A few drams of turpentine or an ounce of powdered alum to a quart of enema solution also acts well. Much care must be taken to prevent perianal irritation.

Skin is to be kept from pressure by air or cotton doughnut-shaped "rings," and alcohol or alum solution sponging is to be freely employed. Frequent changing of position is an excellent preventive of bedsores. The legs will have a tendency to flop sidewise, and pillows or other padded supports must be used to keep pressure off the outer margins of the knees and ankles. The heels are kept off the bed by "rings" through which the os calcis protrudes, or by a soft roll of cotton placed just above the tendo Achilles.

No *prolonged pressure* of any sort can be permitted, and the ingenuity of the attendant will many times be called upon to devise new ways of preventing added pressure necrosis.

Bed-sores once formed from decubitus are washed with a weak antiseptic solution daily, and if sluggish are stimulated by iodin, silver, or the curet. Balsam of Peru (pure or in 10 per cent. solution in castor oil) may also be poured over them and a gauze dressing applied. When granulation is under way, scarlet red ointment makes a good dressing occasionally (see Treatment of Ulcers, p. 41).

Exposure of the wounds to sunlight and the open air is probably the best element of treatment next to freedom from pressure. Odorous sores are benefited by permanganate of potash, or by a solution of iodin (1 dram to 1 pint) or creolin (1 : 100).

(*B*) *Local Treatment* (*Bone and Cord*).—*Non-operative.*—Naturally much depends upon the site and extent of the lesion and whether or

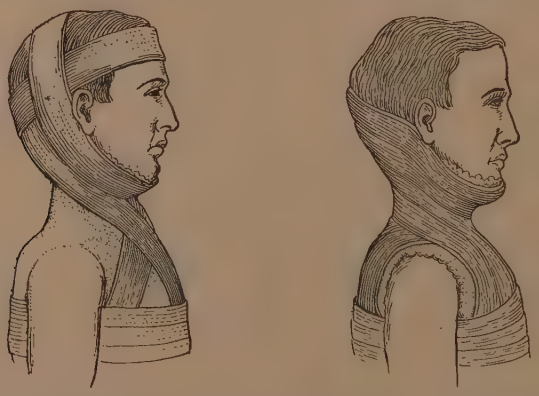
not there are associated injuries. If the treatment is to be non-operative, and if there is deformity of the spine (judged by obvious symptoms or radiograph) it is proper to consider the advisability of correcting it.

Kyphos and lateral rotation are the usual malalignments, and the former is usually amenable to correction by (1) direct pressure aided

Fig. 477.—Extension in fracture-dislocation of spine.

by (2) backward flexion (extension), or (3) suspension by a pulley fastened to the chin (Fig. 477), or (4) opposed by traction at head and feet with the patient prone and the head in an apparatus like a "jury-mast."

When it has been corrected, a plaster-of-Paris jacket is applied with plentiful padding over the deformity (Fig. 478). Sometimes efforts



a *b*

Fig. 478.—Plaster-of-Paris dressing in cervical spinal injury: *a*, Dorsal flexion of head; *b*, ventral flexion of head.

of this sort increase the symptoms, and if so, immediate operation should be done.

If there is demonstrable fracturing of the arch, much pressure or manipulation is likely to be very dangerous. If the bodies are much

crushed, little or no impression will be made on the deformity by external force.

Operative Treatment.—This has already been described under Contusion of the Cord (see page 517).

If the *cord* is found to be lacerated, the fragments are coapted by fine silk sutures introduced sufficiently far from the edges to permit their meeting when traction is applied. If the gap is too wide to be bridged, or if the laceration has caused pulpification, it is advisable to use the posterior root above and stitch it to the root below so that they form a bridge. If the roots are not strong enough, a strand of the erector spinæ shining fascia can be taken from the edge of the wound and implanted to bridge the gap. An intercostal or other nerve may be used for a similar purpose.

In the presence of exceedingly great mutilation, the advisability of amputating and then suturing each end of the damaged cord must be entertained. This has been done on a few occasions apparently with some success; but in the vast majority of cases the procedure is unnecessary and needlessly hazardous.

Muscles are kept under control by suitable devices so that contractures do not occur, notably drop foot and bent knees.

Massage, electricity, vibration, "health exercisers," and other *gymnastic methods* are all very valuable and their use can begin after the first week. Deep breathing and dumb-bell exercises are useful in preventing hypostatic pulmonary changes.

PENETRATING WOUNDS OF THE SPINE

The conditions here are practically those of compound fracture, and the treatment differs only in so far that it generally is modified by associated injuries, usually those to the lung, liver, stomach, or intestines.

Bullet Wounds.—If conditions permit, and the bullet is located with sufficient accuracy (by the history, symptoms, or radiograph), it should be removed at once.

All grades of cord laceration are encountered, most of which are due to the bullet, with occasionally the added damage from bony spiculæ. Very exceptionally the bullet may not penetrate the dura, and then the symptoms are wholly due to pressure from it alone or in association with extravasated blood. It has been stated that a spent bullet has reached the spinal canal and dropped into it by its own weight, to be later removed by operation at a distance from its place of entrance; this seems remotely possible.

Stab Wounds.—Sharp-pointed objects, like daggers, knives, bayonets, hat-pins, glass, and other spiked missiles, occasionally penetrate an intervertebral disk, causing laceration of the cord of varying degrees.

These cases are of importance from the standpoint of rarity more than because of their symptoms or treatment, as the latter have already been discussed in connection with the lesions usually associated.

Spinal Cysts and Serous Meningitis.—Occasionally pressure effects are produced by a more or less circumscribed collection of cerebrospinal fluid following various sorts of intraspinal trauma, notably hematomyelia, contusions, and fracture-dislocations. In the majority of instances the entertained diagnosis has been localized pressure from blood or bone, and less often intraspinal tumor has been assumed to exist.

At operation (or autopsy) a collection of cerebrospinal fluid under tension has sometimes been released, and in some cases this is seen to be confined in a more or less cyst-like wall. Occasionally these cystic cavities are quite numerous and not unlike those found in syringomyelia.

The distinguishing feature of all these cases has been a history of intraspinal injury with recession of symptoms for a certain period, and then a stationary stage, with perhaps later a period of accession. In all there are definite evidences of localized intraspinal pressure manifested by sensory and motor signs not unlike tumor manifestations. Many of these give *x*-ray corroborative signs.

These cases are to be distinguished from syringomyelia with which they are related clinically, but not etiologically. Some of these cases because of radiating pain are diagnosed as rheumatism, sciatica, or neuritis until the underlying true cause is demonstrated.

CHAPTER XIII

INJURIES OF THE CHEST

Anatomy.—The bony cage constituting the thorax is made up of the cartilaginous *sternum* in front, the twelve ribs on each lateral margin, and the *dorsal spinal column* posteriorally. This architecture combines strength and elasticity with ample protection, and doubtless accounts for the freedom from intrathoracic as compared with intracranial or intra-abdominal injuries. The muscular and ligamentous arrangement affords added support and protection to the subjacent parts and also to the blood-vessels ramifying near the surface.

The *intercostal* vessels run in a groove on the under surface of each rib, and thus are well protected and are almost never involved in fractures.

The *internal mammary* vessels are on the posterior surface of the sternum; injury of these is also extremely rare except from perforating injury.

The *pleura* lines the inner surface of the ribs and invests the lungs. The lower limits of this serous pleural sac are shown in Fig. 265, *a*, *b*, and this distribution is important in showing what relation if any exists between a broken rib and a pleurisy, it being well recognized that *traumatic pleurisy* is localized to the site of injury.

The *lungs* occupy the entire right half of the thorax with their three lobes (upper, middle, and lower; or superior, middle, and inferior), and most of the left half with their two lobes (upper and lower; or superior and inferior). They are very rarely involved in indirect violence causing contusion of the chest, and rather uncommonly affected even by direct violence, as by rib puncture. Perforations of the lung from bullet, stab, or other wounds are generally less serious than the anatomic and immediate physical conditions indicate.

Traumatic pneumonia, like traumatic pleurisy, begins at the site of injury and usually appears within two or three days, and may become manifest within twelve hours; it is always of the *lobar* type and generally runs a rapid course.

The *bronchi* generally are only involved as a part of injury to adjacent organs.

Heart involvement is always the outgrowth of *direct violence*, usually from stab and less often from bullet wounds.

This organ is so surrounded by the lung that injury to it is relatively impossible without first damaging the intervening structures; likewise, it is further protected because of its motility in a dangling position.

Mediastinum injury is of surgical importance only because it is sometimes associated with injuries involving the adjacent contents of the thorax.

Thoracic duct injuries are exceedingly rare alone, and are of importance only because of the coexisting damage to nearby parts.

Esophagus injury is commoner from within than without, and any external damage is generally a part of fatal penetration of neighboring structures.

As in cranial and abdominal injury, the measure of damage is the extent of involvement of the thoracic contents, and thus injury may affect the—

(1) *Chest wall* alone—*extrathoracic* injury.

(2) *Chest contents—intrathoracic* injury.

Chest Wall or Extrathoracic Injury

This may be in the nature of contusions, muscle ruptures, wounds, fractures, and dislocations.

Contusions are generally from blows, falls, squeezing, jamming, and allied causes, such as may result from fights, contact with moving objects, and railroad and vehicle accidents.

Symptoms.—Shock of varying extent occurs and the patient is generally "knocked out," and may even become cyanotic in an interval during which respiration is temporarily abolished or interfered with. Thereafter *local pain* is felt and respiration is shallow or abdominal for a varying period.

Swelling and *ecchymosis* soon appear; if the latter is early in onset, it may be inferred that only the superficial parts have received the brunt of the force. *Hematomas* may form, but the texture of the muscles is less favorable for their development than in the abdominal wall. *Pain on motion* and *pressure* is present and is increased by deep respiration; but the absence of crepitus, point-pressure pain, and false motion excludes fractured rib.

Treatment.—This requires the external applications (ice or heat), and in some cases the use of adhesive straps, as in fractured ribs. Hematomas uniformly respond to pressure.

The *course* is toward rapid recovery, although the discoloration and pain on usage may persist for several weeks.

Ruptured muscles sometimes are the outgrowth of the same causes producing contusions, but more commonly result from violent efforts, such as coughing, sneezing, lifting, throwing, or wrestling. They are rather uncommon, tearing or rupturing of the sternal attachment of the pectorals, and the digitations of the serratus magnus and the latissimus being most common.

Symptoms are like those of contusion, but occasionally a gap or depression in the muscle is apparent to sight and touch.

Treatment.—This is mobilization by adhesive straps. I have never known a case where suture was needed.

The *course* is toward perfect recovery.

Wounds are of all types and are inflicted by knives, cutting instruments, glass, spikes, nails, and various other more or less sharp materials. Bullet wounds are quite prone to richochet about the chest from a rebound off the rib or sternum. I have seen several cases where a .32 or larger calibered bullet at close range has struck the lateral chest wall, caromed against a rib, and passed half-way around the chest, to appear subcutaneously almost at the level of entrance. Such deflected bullets rarely fail to lodge in the soft tissues, as their force is mainly spent at the time of initial impact. A ridge of swelling or line of ecchymosis often marks their path around the chest.

Symptoms are those of any other wound, and bleeding is usually moderate unless an intercostal, internal mammary, or main branch from the axilla is cut.

Treatment.—Primarily this should aim at the removal of any foreign body, especially glass and metal fragments or pieces of clothing. Disinfection by iodin is to be practised (as outlined in the *treatment of wounds*), and the bleeding is controlled by pressure or ligature. If necessary, the original wound must be enlarged enough to bring into view any spurting or oozing vessel otherwise uncontrollable. All such wounds should be drained for a few days. Bullets lodged subcutaneously are best left alone for three or four days or even longer, and they are then removed under local anesthesia after reaction has subsided. If infection of a wound occurs, the customary treatment is given. The patient should be kept off the back, so that hypostatic pneumonia may be prevented.

The *course* is generally favorable and the prognosis is that of infection.

INJURIES OF THE FEMALE BREAST

Contusions.—These are exceedingly common, and there are few women who have not at some time been subjected to such an accident.

Causes are blows or falls, and contact with moving or stationary objects, notably articles of furniture and the edges of doors and similar projections. The violence is rarely received at the summit of the breast, but ordinarily at the outer lower margin.

Symptoms are pain, nausea, and sometimes decided evidences of syncope or shock.

Locally, swelling and redness are very promptly apparent, and usually within a day discoloration and induration follow. The area involved is generally sharply circumscribed to sight and touch, and pain is marked at first and is notably increased by motion and palpation. Fever is an occasional accompaniment. Superficial bruising is generally more diffused and signs of hematoma do not then appear. Localized point tenderness, fluctuation, brawniness, axillary gland involvement, and fever indicate *abscess* formation; such a sequel is commonest in nursing women or those who have borne children, and where fissured nipples have existed. I have, however, known axillary adenitis to occur and subside without abscess formation. After local signs disappear, an area of induration may remain, and this is generally relatively hard, mobile, and painless. Still later, the indurated area may soften, undergo cystic formation, be absorbed, or persist. The ordinary case begins to show signs of subsidence within a week, and the discoloration disappears in a few weeks, and all indications are usually gone in a month or six weeks, and examination then discloses nothing aside from slight local pain on firm pressure, but of which the patient may be unaware even if tightly laced.

Treatment.—This demands absolute rest, freedom from pressure, and the external use of cold lotions. Under no circumstances is rubbing, massage, cupping, or similar interference warranted; such intervention is likely to do great damage. The breast should be suitably supported in a properly padded sling and held at an elevated angle of comfort. If an abscess forms, incision and drainage are indicated, the opening being made in a line radiating from the nipple toward the chest, like the spokes of a wheel. It should be liberal at first, so that painful repetition will be prevented; a Bier suction cup is a very efficient aid, as by its use a smaller incision is adequate. Drainage should be of gauze packing for the first few dressings, so that contrac-

tion will be prevented. *Cysts* are watched, and aspirated or excised if they fail of absorption.

The *course* of the vast majority is toward recovery, and the incident is usually forgotten until after a lapse of some months or years a tumor of the breast appears and the original or another injury is promptly accused. The vast majority of the laity and a great many physicians still correlate a tumor of the breast and an injury despite the fact that such a relationship is exceedingly rare and rather improbable in the light of modern ideas as to tumor formation in general. If any injury is to bear a causal relation to a subsequently developing breast tumor, malignant or otherwise, the following factors must pertain:

(1) The tumor must involve that part of the breast originally injured.

(2) The breast must have been previously sound and uninjured and preferably known to be so by recent examination.

(3) The interval between the injury and the development of the tumor must have been filled with symptoms showing rational progress toward a neoplasm.

(4) A reasonable time must have elapsed, usually not more than six or nine months, before the tumor was apparent; and the nearer the accident to the time of tumor development, the greater the probability of relationship.

(5) The size, symptoms, and especially the pathologic type of the tumor should be such as to be reasonably sure that the injury was more productive than another more usual and ordinary source of origin.

(6) No signs of tumor formation must exist elsewhere.

How far an injury may accelerate a tumor already present is difficult to decide; answer to this would be largely predicted on the history of the patient and the tumor, the manner of the accident, and how close the tumor was to the place struck, and what symptoms immediately and subsequently followed. As is well known, many of these tumors are independently subject to periods of quiescence, remission, and accession; for this reason very careful analysis of all the facts must be made before an accident is looked upon as the sole aggravating element. The operative or pathologic examination would be exceedingly important, and if there are any areas of hemorrhage apparently of external origin, either outside or inside the tumor, such evidences might prove corroborative. It is my experience that the majority of patients seeking advice for a tumor of the breast assert that the

breast had been injured at a more or less distant period, but except in one instance I have never been able to satisfy myself that an accident appeared wholly responsible for the tumor. This was in a forty-five-year-old married woman who was of unusual physique and who never had any lactation troubles and whose family and previous history were negative. Some few months before I examined her she had fallen from the platform of a steam railway coach striking her right breast against the last step in her descent. She sustained sundry injuries, notably a fracture of her ankle, and a localized painful swelling of the outer margin of her breast. This last soon became ecchymotic, and when the discoloration disappeared a small lump remained and gradually increased in size until it became so large and painful that she sought additional surgical advice regarding it. It appeared that about four or five weeks before her accident she had some pain in the vicinity of her opposite breast, and her family physician then took occasion to examine both breasts and found them normal. The tumorous breast was removed about nine months after the accident and the growth proved to be carcinomatous.

INJURY OF THE MALE BREAST

This requires no special mention to differentiate it from contusions of the rest of the chest wall.

Chest Contents or Intrathoracic Injury

This may be the outcome of non-penetrating or penetrating injuries, and the effects obviously depend on the part affected; hence discussion will include injury of the pleura, lung and bronchus, heart and pericardium, mediastinal contents (esophagus, thoracic duct vessels).

INJURY OF THE PLEURA

Causes.—From contusions capable of producing so-called "concussion of the chest" or "commotio thoraci, "pleurisy may rarely follow at the site of the impact. It is an unusual occurrence in the absence of penetration of the pleura through the chest wall or from a broken rib; of all causes the latter is the commonest, and next in frequency is intercostal penetration from stab and bullet wounds, with or without penetration.

Symptoms.—With or without penetration the signs usually appear within the first day, and if delayed beyond three days (in the absence of wound infection) the traumatic origin is to be doubted. The

onset is with localized pain, difficult and therefore shallow and rapid or "cog-wheel" breathing, slow and interrupted speech, cough, fever, and sometimes a chill. *Locally* will be found crepitus at the end of inspiration, with altered voice or tactile fremitus. If fluid is present (serum, blood, or pus) the added signs will be dulness or flatness on percussion, and diminished or absent breathing and voice sounds.

The ordinary form is a localized dry (fibrinous) pleurisy, and the wet (serofibrinous) or pleurisy with effusion form is a rare sequel. The hemorrhagic form is generally associated with injury of the lung, and then there often is a combined pneumothorax.

Subcutaneous emphysema is a usual accompaniment when laceration of the pleura occurs, and it may invade the entire chest and even extend to the abdomen, neck, and face.

Treatment.—This is appropriate for the initiating cause, and where possible the chest should receive the support and rest afforded by adhesive straps. Hot applications provide relief from pain when the straps are inefficient or inapplicable, and sedatives are used for the cough when required. In penetrations from without, probing or other interference is most unwise, as nothing is to be gained by searching for an embedded and perhaps hidden foreign body or a path of laceration. If later irritative signs indicate that a foreign body is mischievous, interference may be considered when proper *x*-ray localization is made.

The development of hypostatic pneumonia is best prevented by keeping the patient off the back. Alcoholics need stimulants and sedatives from the outset to prevent delirium tremens.

The **course** is generally short and the active signs generally subside within a week.

The lacerations due to penetration generally heal kindly and the gradual expansion of the lung soon restores the vacuum by driving out the escaped air. For a variable time some pain will be locally noted on deep breathing, exertion, and climatic changes, but these regularly disappear. Adhesions of a lasting character very rarely form, and I have known of no case in which they affected respiratory capacity noticeably. I have never observed a case of chronic or tubercular pleurisy to arise from injury.

INJURY OF THE LUNG

Causes.—Contusions of severe character, notably those resulting from sudden localized blows, may rarely damage the lung close to the site of impact, in the absence of penetration of the chest wall or rib

fracture. Such an occurrence may result in *pneumonia* or *laceration*, and the same sequelæ may arise from penetrating causes from without, notably from bullet and stab accidents.

Symptoms of pneumonia coexist with those of pleurisy ordinarily (traumatic pleuropneumonia), together with bloody sputum, sharper pain, chill, and elevations of pulse, temperature, and respiration; the pulse averages about 120, the respirations 30, temperature 104° F. The physical signs indicative of consolidation also exist, such as dulness or flatness on percussion, bronchial breathing, and crepitant râles. If much air escapes, variable subcutaneous emphysema appears and the evident *pneumothorax* presents metallic tinkling and the various other auscultatory signs. When blood is effused the *percussion* sound is dulled and breath and voice sounds are less audible. With pneumonia and laceration there will be the combined evidences of hemopneumothorax. Bloody sputum is always an indication of some pneumonia or laceration, or both. The onset of the foregoing symptoms is very prompt, and in the majority of cases they appear within the first day and are exceedingly rarely delayed beyond the third day.

In *penetrations from without* the external wound rarely bleeds much unless a main blood-vessel has been damaged or an extensive gaping wound allows the audible exit of frothy blood at each expiration.

Collapse of the lung promptly occurs when the thorax is penetrated, and thus the viscus rarely comes into view.

Bullets frequently penetrate the entire chest wall from before backward, or the reverse, and at the place of exit are often visible or palpable. In such an event, blood issues at the place of entrance, and emphysema is evident at the site of exit.

So-called rare cases of "fracture of the lung" or "rupture of the lung" without external wound are instances of intrathoracic laceration, and these may be very extensive and result in "pulmonary apoplexy" and prompt death. Cases of less extent present signs of hemothorax or pneumohemothorax and generally recover.

Treatment.—This designs to interfere as little as possible, and hence developments are awaited. No good ordinarily can come of seeking immediately to check a pulmonary hemorrhage or remove a foreign body, but on the contrary much added damage may be imposed. If an embedded splinter or missile projects from the chest wall it may be imprudent to immediately remove it if it is acting as an effective tampon; however, it should be extracted if the reverse pertains, and, of course, it is subsequently removed when conditions permit or demand. Saw-mill accidents are of this type, and embedded sword-like pieces of

wood have been forcibly removed by spectators, with the result that immediate fatal hemorrhage ensued.

Wounds are iodin treated and loosely sutured or packed, and they are always drained.

If respiration is embarrassed because of the *hemothorax* it is proper to aspirate the blood through a needle introduced, preferably, in the seventh or eighth intercostal space in the axillary or scapular line; this procedure may be repeated if necessary.

The *pneumonia* is treated by such therapeutic means as would be employed ordinarily. These patients seem desperately ill, but very many of them recover surprisingly well considering the nature of the original injury and the apparent damage to the lung itself. Alcoholics are bad risks and every attention is given to prevent delirium tremens; it ordinarily appears within the first four days after this or any other form of injury. The patient should be frequently rolled gently from side to side to prevent hypostatic changes, and this is done despite the location of the wound. Rest, food, and systemic support are the cardinal needs. Unlike ordinary surgical pneumonia, these cases do not act well out-of-doors until convalescence is under way.

The removal of an embedded bullet or other foreign body should not be undertaken at an early stage unless there is some explicit indication, and this arises very rarely. Localization by frequent *x*-ray examination is a necessary preliminary, and no foreign body should be sought unless it inevitably is the source of symptoms.

Persisting sinus, cough, or *abscess of the lung* may justify interference, and operation should then be guardedly undertaken with intratracheal or negative pressure anesthesia. Persistent pressure or irritation from any source except a foreign body is almost unknown, as the lung soon accommodates itself to any such invasion; for this reason fractured ribs with lung involvement practically never require operative interference on the theory that callus or a bony splinter is acting as an irritant.

The **course** in the recoverable cases indicates signs of improvement after the third day, and patients surviving until then generally recover. The convalescence from that time is proportionate to the initial extent and source of injury, and it is generally rapid when wound infection is absent. After the patient is up and about there will be local pain and soreness on deep breathing and motion and during weather changes, but all of these eventually disappear.

Traumatic tuberculosis is said to occasionally occur, but I have never seen a case in which injury was the demonstrable cause. I recall

about a half-dozen cases in which it was claimed to be the outcome of various accidents, but in every instance other more usual and adequate factors were evident. It must be an exceedingly rare sequel of chest injury to have been alleged in so small a number of litigated cases in an experience totaling knowledge of about 50,000 claims of personal injury. I have never seen or heard of a case in private, dispensary, or hospital practice.

For any connection to be established it must appear that: (1) The patient was free from tuberculous signs before the accident; (2) the injury was to the chest and of a sufficient degree to at least induce traumatic pleurisy or pneumonia, or both, at the site of the violence; (3) the interval between the injury and the development of tuberculosis must be filled by symptoms showing progress toward the fully developed disease; (4) there must be no preceding or succeeding cause that might be regarded as equally or even more liable to induce the affection.

It is, of course, certain that the tubercle bacillus is the actual inducing or direct cause, and that any injury is but an indirect or predisposing source for the malady.

Bronchus injury from without is exceedingly rare and is generally an accompaniment of fatal lung injury, ordinarily of the penetrating type.

INJURY OF THE HEART AND PERICARDIUM

This organ is so well surrounded by lung that injury to it is practically always accompanied by signs of pleural and pulmonary damage. According to Latham, for practical purposes the uncovered part of the heart may be said to lie within a circle 2 inches in diameter on the middle of a line between the nipple and the lower left end of the sternum.

Cardiac damage from chest wall or **non-penetrating injury** is an exceedingly rare injury, as any violence great enough to reach the heart from impaction on the chest wall would almost of necessity induce bony, pleuritic, and pulmonary complications in the form of fracture, pleurisy, pneumonia, or lacerations. Blows directly over the precordial area are capable of inducing symptoms of cardiorespiratory collapse and shock of all grades, and the *treatment* and *prognosis* is that of shock. Crushing injuries may lead to rupture of the heart and pericardium in conjunction with other fatal lesions.

There are no well-authenticated cases of *traumatic endocarditis* arising solely from violence to the chest wall; and in those cases in

which murmurs and other evidences appear after injury, the condition is probably one of disturbed compensation.

The same is true of *traumatic pericarditis*, and all such cases must be scrutinized unusually closely before injury is regarded as the producing cause. This is especially true in the presence of infectious, rheumatic, arteriosclerotic, nephritic, or other more usual producing or associated sources of origin.

Penetrating injury that demands surgical treatment occurs usually from stabbing or shooting accidents, the former being commonest, because the latter are so frequently immediately fatal.

There are numerous successful cases of heart suture for wounds, and in a tabulation of 218 operative cases of injuries of this nature Frazier states (*Progressive Medicine*, March, 1913) that the mortality was 55.5 per cent.; the mortality is probably much higher than this, as fatal cases are infrequently reported.

Autopsy findings seem to indicate that the right ventricle is most often penetrated; but in the operative cases the left ventricle has been affected in 55 of 125 cases reported by Rehn (with recovery in 45 per cent.), and the right ventricle in 50 cases (with recovery in 32 per cent.). The auricles were about equally affected; the left showed 2 recovering cases, the right, 4 recovering cases.

Symptoms.—These depend in great part upon the nature and site of the penetration. If the depth and degree of the wound is slight (as from a needle or a hat-pin) there may be no immediate serious symptoms, and, indeed, no suspicions of a penetrating wound may be aroused. The intermediate cases (like those from thin knives or sharp-pointed tools or missiles) and the palpably evident cases (as from bullets, stilettos, carving-knives, ice-picks, or prong-shaped missiles) quite regularly give signs corresponding to the following: The patient is in a state of *shock* and usually *unconscious*. The wound ordinarily does not bleed much unless it involves a vessel or is in direct line with that in the heart, and then projectile systolic bleeding is evident. The *respiration* is embarrassed, and dyspnea, cyanosis, and lividity may then exist, although these are usually signs of intrapericardial pressure. The *pulse* lacks volume and usually is rapid, feeble, and irregular; the left-sided radial pulse may be imperceptible or less forcible than the opposite. *Pallor* may appear as one of the signs of intrathoracic bleeding.

Auscultation shows *muffled*, *unusual*, or *distant heart sounds;* if the pleura and lung are also involved, hemothorax signs may also exist; occasionally it is said that the blood can be heard to spurt at each cardiac systole. Crepitation and emphysema signs may appear.

Percussion gives evidences of hemopericardium if the pericardial sac is untorn or plugged, and with this there will be signs of cardiac compression, such as cyanosis and lividity. Abdominal rigidity sometimes occurs even where the abdomen itself is uninvolved.

Main reliance is placed upon the (1) location and source of the wound; (2) the character of the pulse and heart sounds; (3) signs of hemopericardium.

Treatment.—Probing, or *any exploration*, without preparation for opening the thorax, if necessary, will do great damage and may lead to instant death or infection. In cases where developments are being watched, the treatment is for shock, except that cardiac stimulants obviously are not employed.

In case of reasonable doubt it is safer to explore the original wound along an intercostal space, and if the bleeding is found to be from the

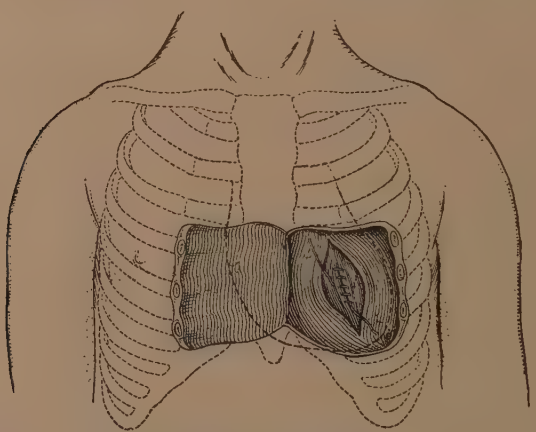


Fig. 479.—Exposure and suture of heart and pericardium.

heart, this incision may be made part of the main thoracotomy; if possible, the fifth, sixth, or seventh costal cartilages should be included in this incision (Fig. 479).

After the pericardium has been reached, it is opened along the desired line and the blood rapidly removed so that the bounding heart may be inspected. In cases with spurting of blood a finger is placed over the wound during systole, and then a silk threaded fine full-curved needle ties the edges of the wound in diastole, and from this suture the organ is "dangled like a jumping fish" until all the wound is closed by interrupted stitches deeply passed. In those cases of massive bleeding it may be necessary to manually compress the heart until the source of bleeding is located. Another effective method is to compress

the venæ cavæ at their entrance into the auricle for a few seconds (Rehn's method). After all the blood has been removed the pericardium is loosely sutured by interrupted stitches, but it should not be drained unless gross evidences of infection are apparent; if drainage is required, a folded strip of rubber tissue or thin rubber tubing is used.

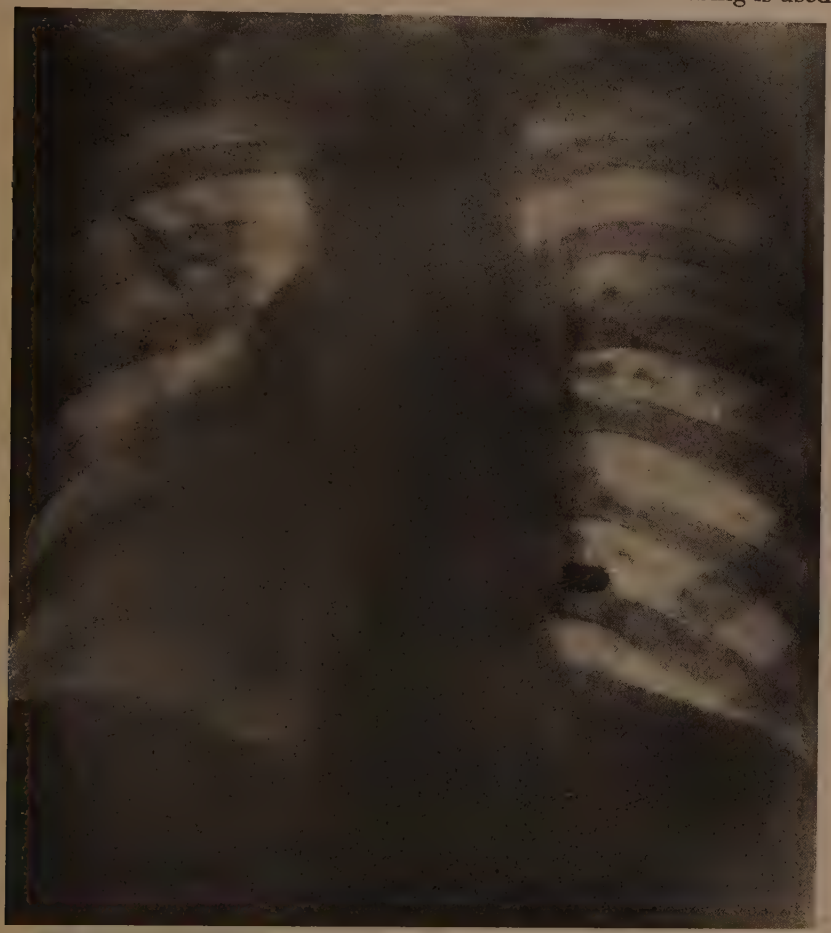


Fig. 480.—Case of R. S., 38-caliber bullet entering posterior axillary region and lodging in the eighth intercostal space close to spine. Missile not removed. Patient, a police officer, remains perfectly well.

Interrupted sutures join the bony, muscular, and skin layers, and drainage by rubber tubing or tissue is provided, so that the thoracic cavity is drained through the lowest angle of the wound. The unconscious patients may need little if any anesthetic until the blood is allowed to escape from the pericardium; but from that time on struggling may seriously interfere, and for that reason anesthesia is preferable from

the beginning. Ether by the drop method or intratracheal anesthesia is the best form of general narcosis.

Postoperative treatment is directed toward relief of shock and the prevention of pneumonia or further bleeding. The erect or somewhat elevated posture will prove most efficient, and morphin, saline solution rectally, and cardiac stimulants are used as indications demand.

The *course* is dependent upon the outcome during the first few days, as cases surviving that long ordinarily recover, even if pericarditis, pneumonia, pneumothorax, and some sepsis follow as later complications.

Foreign Bodies in the Heart or Pericardium.—These are ordinarily bullets, needles, tools, or fragments of metal or glass. Occasionally they may remain encysted, and some freak cases are recorded in which a marvelous tolerance seems to have existed. The majority of such cases end eventually in death either from direct involvement of the heart or projection of the invader into the circulation, leading to hemorrhage, embolism, or thrombosis. Radioscopy is a valuable aid in determining the exact location of such foreign bodies and the advisability of removing them.

ESOPHAGUS INJURY

This is rare as an isolated event from external violence, stabbing and shooting accidents furnishing the few instances of damage from without.

Symptoms are not distinctive and the signs are generally such as follow hemorrhage or injury to the thoracic viscera coincidentally involved. Bloody vomitus may occasionally be suggestive. Esophagoscopic examination would be helpful.

Treatment.—This is wholly for the associated injuries, and the aim is to stop bleeding and prevent or minimize infection. Thoracotomy for esophageal injury must, of necessity, be rarely advisable. Stricture due to initial damage, or that dependent on infection, is treated in the usual manner.

THORACIC DUCT INJURY

This is exceedingly rare and the diagnosis is usually made by the escape of chylous fluid (white and viscid) along the track of a bullet or stab wound. Emaciation promptly follows from inanition.

Treatment.—Primarily this is given for the associated injuries, and when the chylous fistula appears, efforts are made to block it by cauterizing or cureting. Thoracotomy ordinarily would be a last resort.

CHAPTER XIV

INJURIES OF THE ABDOMEN

These can be discussed in relation to accidents resulting in damage to the (1) *abdominal wall*, (2) *abdominal contents*.

Abdominal Wall, External, Non-penetrating, or Extra-abdominal Injuries

These arise almost always from *direct violence*, notably from blows, jammings, kicks, falls, missiles, vehicles, or falling objects.

Less commonly *indirect violence* is the cause, as from stretching, wrenching, or similar twisting forces applied at a distance.

The effects depend mainly on:

(*a*) *The individual:* Obviously a fat or protuberant abdomen may be less affected than one less well padded.

(*b*) *Manner of accident:* The broader the surface affected, the less likely the localizing effects.

(*c*) *Place of impact:* The nearer to the solar plexus the force is received, the greater the systemic effect.

The chief injuries of this region are contusions, sprains, wounds, and ruptured muscles.

CONTUSIONS

These may be localized or diffused, depending upon the causation.

Symptoms.—If severe, there is ordinarily abdominal shock, with difficult breathing, pallor, pain, and vomiting, with associated coma in the severer forms; the patient, in a word, is "knocked out." On reviving, the remaining signs may be costal respiration and pain, increased on pressure and motion; later, discoloration follows the original pink or red area of impact. Local effusion of blood may be circumscribed, and thus form a *hematoma* that may be subcutaneous, intramuscular, or just outside the peritoneum; the first is the common form. These collections of blood at first are soft and fluctuant, but later may become quite hard and simulate tumors. Not infrequently they become infected and end as abscesses. I recall such a termination in a patient on whom I operated for a suspected appendiceal abscess.

The **differential diagnosis** as between extra- and intra-abdominal injury in some cases is exceedingly difficult, and the main reliance is

to be placed upon the association of symptoms, and the information gained by the presence or absence of blood in the vomitus, stools, or urine. Persistent or localized pain with rigidity of the abdominal wall and increased pulse-rate are exceedingly suggestive of visceral injury if the inflicting force has been adequate. Tympanites and the obliteration of liver dulness and other percussion changes are less reliable, as these are often relatively late in onset.

Treatment.—The shock is treated in the ordinary way; if stimulation is needed, it is best given hypodermically until proof is offered that the gastro-intestinal tract is uninjured. For the same reason oral or rectal stimulation or catharsis is to be avoided.

(1) Rest in a comfortable position, (2) an ice-bag, and (3) a hypodermic of morphin is the treatment-trinity most often useful. In less severe manifestations, cold applications or some mild lotion will prove effective.

Hematomas are usually controlled by pressure until absorbed; they may occasionally be aspirated under aseptic precautions, and less rarely incision is justifiable. Interference of this sort should not be attempted until pain is greatly abated, and until the acute reaction passes. The vast majority of such effusions subside under pressure and massage, not excepting the rather huge collections that so commonly collect in the inguinal and iliac regions. If an abscess forms, it will become manifest by local heat, tenderness, and a brawny feel, and incision and drainage are then required, a guarded hypodermic thrust having previously located pus. Incision should be in the line of the underlying muscle-fibers.

Results.—These cases regularly respond well unless injudicious treatment causes infection and sinus formation. It is occasionally asserted that a contusion or hematoma in the inguinal region predisposes to hernia, but this of necessity must be quite conjectural and from an anatomic standpoint is relatively impossible.

WOUNDS

Bullets, knives, glass, tools, metal and wooden splinters, or spikes may penetrate varying depths, producing more or less irregular lacerated wounds.

Symptoms.—Shock and bleeding obviously vary with the nature, extent, and site of the damage. Wounds in the vertical axis are more likely to give more symptoms than those in the transverse or muscle plane direction of the abdomen. If the rectus muscle is penetrated along the line of the deep epigastric vessels, hemorrhage is apt to be

profuse; the same to a less extent is true of wounds involving the suprainguinal regions. Bullets may ricochet more or less around the abdominal wall from an initial impact and rebound from a rib, iliac crest or pubic rim, and lodge subcutaneously or at a palpable depth from the surface.

Treatment.—The wound is flooded with iodin and bleeding points are then ligated, and the wound edges are retracted and search is made for any foreign body. Probing should be scrupulously avoided, and if the entire extent of the wound is not exposed on retraction, it should be enlarged sufficiently to bring all of it into view when necessary. Silk, horsehair, silkworm or catgut sutures are then introduced, and the lower angle of the wound is drained by a twisted strand of the suture material or a few folds of gutta-percha (rubber) tissue; no wound should be tightly sutured and many of them are best treated if allowed to remain open until the possibilities of infection disappear, and later, usually after the third day, they can be coapted by suture or adhesive strapping without danger. The primary dressing is best made of gauze moistened in iodin (1 dram to 1 pint water), or 50 per cent. alcohol, or other non-irritating antiseptics. Drainage can be removed by the third day if purulent or serous leakage does not contra-indicate. If the muscle layers are cut, they should be sutured tier by tier, drainage entering to the depth of the cavity. So-called "brush burns" or multiple abrasions or superficial lacerations or denudations do best with preliminary iodin sterilization followed by mild antiseptic dressings or exposure to air and sunlight. All bullet wounds and others likely to be contaminated by street, garden, or stable dirt should receive preliminary injections of tetanus antitoxin.

Results are good and directly proportioned to the amount of initial and subsequent infection; this means that careful sterilization, coaptation, and drainage are important elements. Ventral hernia is a rare sequel and is most likely where the fascial and muscle layers have been extensively torn.

SPRAINS AND RUPTURED MUSCLES

These occur usually in association with other injuries more or less adjacent to the abdominal wall, such as to the thighs or hips, and they also result from direct twists or pulls.

Symptoms are pain and tenderness on pressure and motion; diffused ecchymosis generally appears later.

Ruptured muscle is rare, and when it does occur the rectus is most often involved, this then giving exaggerated signs of sprain and a

definite depression along the muscle course that may be visible and generally is palpable. Hematoma or rather extensive ecchymosis is also present, together with local pain on pressure, motion, or respiration.

Treatment.—*Sprains* respond to local anodynes, massage, and adhesive strapping.

Ruptured muscle is coapted by posture and adhesive straps when possible; otherwise it is sutured by open operation. Cases that do not show definite separation require little, if any, treatment.

Results are good and there are ordinarily no after-effects.

Abdominal Contents, Intra-abdominal or Penetrating Injury

These so-called "internal injuries" are relatively frequent and occur from localized or diffused violence, the effects depending upon the origin, extent, and site of the impact.

Like injury to the skull and thorax, such accident may or may not be associated with a wound leading to the surface.

In order of frequency the intestine (chiefly small intestine), stomach, kidney, liver, spleen, bladder, and pancreas are involved either separately or in combination.

Intra-abdominal Injury in General

(*a*) **Without External Wound.**—*Causes.*—Blows, falls, missiles, falling or moving objects, jamming, vehicles (notably run-over accidents) are most frequently the sources of origin. With active digestion, a full bladder, or an enlarged spleen, damage is more likely than when the reverse pertains. A rigid abdominal wall better protects than one that is lax or flabby.

Symptoms.—Shock to some extent obtains in all, but this may be transitory at first and the real import of the accident may not be apparent until the onset of so-called "secondary shock" from hemorrhage.

Vomiting is very frequent and when associated with blood is quite suggestive of stomach or adjacent intestinal injury.

Pain especially if localized and persistent, on motion, respiration, and pressure, is a valuable sign.

Rigidity is the most reliable of all signs, and if progressive is practically pathognomonic.

Respiration is generally shallow and thoracic.

Tympanites is frequently late in onset, and is most valuble when it obliterates liver dulness and when it is progressive.

Dulness in flanks is usually indicative of fluid, generally blood or intestinal contents, and hence is a later symptom.

Hemorrhage is indicated by pallor, thirst, respiratory and pulse changes, and lowered blood-pressure.

Temperature is generally subnormal at first, later rises, and may again fall if blood loss continues.

Pulse-rate is increased, and this is a suggestive sign if the rapidity increases.

Blood in the vomitus, stools, or *urine* is valuable evidence of gastrointestinal and urinary involvement respectively.

Generally speaking, a presumptive diagnosis can be made on the combination of: *Shock*, with or without signs of hemorrhage; *rigidity; local pain; thoracic breathing;* the *facial expression; rapid pulse.*

This class of case generally requires treatment for the onset of peritonitis; the following class, for the occurrence of hemorrhage.

(*b*) **With External Wound.**—*Causes.*—Often due to bullets, stabs, or penetration by spikes, hooks, or more or less pointed objects.

Symptoms resemble the foregoing, except that evidences of internal bleeding are often the chief manifestations. The actual site of penetration is, of course, more readily apparent, although in bullet wounds it may be quite inferential, especially as the history is oftentimes hard to obtain with accuracy, either because the victim is unconscious, unwilling, or fears to incriminate himself or the assailant. In the vast majority of cases omentum protrudes and a very large amount can appear through a small opening due to straining and coughing.

Perforation of the upper is less serious than the lower abdominal zone because of the greater virulence of the intestinal contents.

Treatment.—*Non-penetrating injury* is treated by absolute rest, an ice-bag, and abstinence from food by mouth; rectal interference should be interdicted.

This advice applies *only* to those cases that present no signs or reasonable inferences of either peritonitis or hemorrhage. The presence of the former always indicates perforation of some viscus, usually the intestine. It has been definitely established that peritonitis from external injury does not occur from without, but from within, and is of germ and not traumatic origin, unless the gut or stomach wall has been actually punctured; hence "traumatic peritonitis" now means perforation.

Laparotomy is indicated if (1) there is doubt as to actual conditions; (2) in the presence of rigidity and persistent pain; (3) with signs of

peritonitis or hemorrhage. To be effective it must be prompt, and is demanded usually for involvement of the gastro-intestinal tract.

Penetrating injury, whatever its origin, demands immediate exploration under aseptic surroundings. For this reason the first-aid care of such cases is especially important, and the region of the wound should be suitably protected and the patient placed in such a position that gravity will prevent any further visceral prolapse and allow escaping materials to collect in the pelvis. Before operation the wound and the parts about it are flooded with iodin and the entrance of this antiseptic into the abdominal cavity need not be feared. Preliminary preparations are made for intravenous infusion of saline solution into a vein of the elbow, but this procedure is not commenced until a failing pulse calls for it. Nitrous oxid followed by ether is the best anesthetic. The patient's head and shoulders should be elevated, as this posture seems to limit regurgitant vomiting during anesthesia.

Lines of incision depend somewhat on the site of the perforation, but they are generally made lateral to the median line at the outer margin of the rectus, including the original wound if possible. *In cases of doubt* the exploratory wound need not exceed 2 inches, and through this a small moist gauze sponge may be introduced on a holder to determine the presence of blood or gastro-intestinal contents. If there is no bleeding and if the cavity gives no evidence of gastro-intestinal or bladder contents, then the operative wound is closed tightly and the original perforation is loosely closed and always suitably drained. The presence of blood, gas, odor, bubbles, or suction sounds calls for further exploration, and the operative wound is then enlarged as liberally as may be necessary.

In cases of known intra-abdominal hemorrhage, preliminary bandaging of the thighs at the groin and of the arms at the axilla will reserve a valuable amount of blood to be gradually released into the circulation after twenty or thirty minutes of such constriction. One thigh is first released, then an arm on the opposite side, then the other thigh, and finally the remaining arm. The abdominal cavity may be still further temporarily robbed of circulating blood by the use of the "Momburg constrictor," which is a broad elastic or other bandage applied about the abdomen above the umbilicus and pulled taut enough to produce some lessening of blood flow through the abdominal aorta. (See Fig. 8.)

Procedures vary after the abdomen has been opened, depending upon the findings.

Hemorrhage may be excessive and the entire cavity awash with

blood, clotted or unclotted, or both. Here the object is to locate as quickly as possible the source of the bleeding, disregarding but marking much less important conditions discovered in the search. Bullet wounds are common offenders, and the site of trouble may be in the main vascular supply of a viscus or in the vessels of the mesentery; smaller vessels and those of the omentum commonly cause lesser amounts of hemorrhage, and not infrequently it is then oozing or slow in character. In the search for the bleeding area, preliminary manual tension on the aorta or by some pressure device is exceedingly helpful while the blood is being rapidly removed by large moist sponges. I have found it helpful to use large sterilized bath sponges for this purpose, as their flexibility and absorptive qualities exceed that of gauze for mopping. When at hand, various forms of suction or aspirating devices (like that of Blake, or Pool and Kenyon) are very valuable. Once found, the bleeding area is suitably controlled by a ligature if vessels are involved, and by sutures, ligatures, or packing if a viscus is the source. The remaining blood is then speedily removed, but no attempt should be made to obtain an absolutely dry cavity if the patient's condition does not permit. Intravenous saline infusion is necessary in all these cases of massive hemorrhage, but it should be reserved until the abdomen is opened, and even longer if possible. The amount to be infused varies, but ordinarily the best index is the *volume* of the pulse, and when this is restored to a fair ratio, the infusion may safely cease. I have not observed that hypodermics of strychnin, whisky, camphor, ether, adrenalin, or similar drugs do any good until the heart has some volume of blood to pump, and then they are frequently of great value. These patients may be so exsanguinated that little or no bleeding occurs along the line of the laparotomy incision and the skin may be blanched, the extremities cold, the pulse almost imperceptible, and the abdomen so full of blood that it flows out of the operative incision, and yet they often will recover if the source of bleeding can be found and a saline infusion introduced. Transfusion is usually inapplicable as a primary measure, but may be rarely needed later. The procedure mentioned under Shock (see page 88) for introducing citrated blood may be used here also; if the blood in the abdominal cavity has not been contaminated, there is no good reason why it cannot be collected and immediately infused into the patient.

Closure of the operative wound may be by through-and-through sutures of silk, horsehair, or silkworm-gut when haste is essential; otherwise it is by the usual tier or layer suturing, the skin preferably being apposed by linen, silk, silkworm, or horsehair sutures. The

originating wound is drained and its edges are clipped if bruised or damaged. The foot of the bed is elevated 18 inches or more, hot bottles are placed about the extremities and over the pericardium, and shock is actively combated. In some cases it is a wise precaution to allow the infusion needle to remain in the vein for subsequent use if required, although hypodermoclysis or rectal infusions (drop method or otherwise) usually answer. No rectal medication is, of course, given if the colon has been involved; otherwise higher intestinal involvement does not contra-indicate resort to the so-called "Murphy drip" or drop method of rectal stimulation.

If mesenteric laceration or vessel damage has been great enough to affect the vitality of the adjacent intestine, then primary resection (Murphy button or suture method) may be done; where conditions do not permit of this, the doubtful loop of intestine may be loosely stitched along the line of incision, and if it subsequently undergoes necrosis an artificial anus results and this later can be cared for.

Less severe hemorrhage can be sought for more leisurely and is controllable by suture or packing.

Contusion of viscera without active bleeding often results in the formation of bluish or dark-colored areas of subcutaneous bleeding, notably on the walls of the stomach or intestine from glancing impact. If such areas are not large, and especially if they do not involve the entire lumen, they may remain untreated; if they show a tendency to later perforate (and this may be delayed several days, and then occur suddenly and give signs like a perforating ulcer) it is wiser to resect at once, or to bring the involved segment to the abdominal wall and suture it there and await developments. If areas of hematoma such as these disappear on pressure, or after hot applications are succeeded by a nearly normal color, then more confidence in their ultimate vitality may be entertained; in this respect they resemble the strangulated gut of a hernia.

Perforation or *laceration of viscera* demands treatment, depending on the viscus and the site and the extent of the opening.

Stomach holes or wounds can be closed by purse-string or infolding suture, with preliminary freshening of the damaged edges. If the perforation is close to the cardia or pylorus, the danger of subsequent stenosis may be imminent enough to warrant immediate posterior gastro-enterostomy, but ordinarily suture suffices. Perforations may involve only one wall of the stomach or both; if the latter, access is best obtained by enlarging the anterior opening sufficiently to bring the hole in the posterior border into view, and it can then be suitably dealt with

after being delivered through the anterior opening. The mucous membrane will pout and extrude more than the other layers and will need trimming almost always; but the remaining portions should only be freshened if bruised or otherwise devitalized beyond repair. The suture line may be reinforced by omentum when practicable.

Intestinal holes may be of all degrees, from one or many small punctures to irregular rents (Figs. 481, 482). Circular or overlapping silk or linen sutures are to be used where the lumen is not too seriously encroached upon; otherwise anastomosis by Murphy button, end-

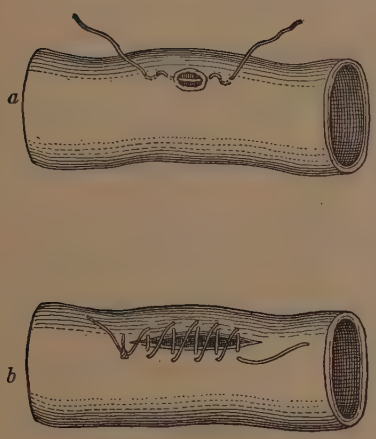


Fig. 481.—*a*, Czerny-Lembert suture of a punctured intestinal wound: *b*, continuous suture of a linear intestinal wound.

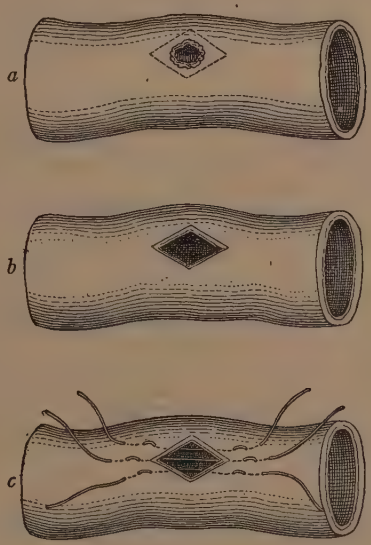


Fig. 482.—Suture of a ragged intestinal wound so that the lumen is not narrowed: *a*, Diamond-shaped outlining for exsection; *b*, area exsected; *c*, Czerny-Lembert sutures introduced and ready for tying in the long axis.

to-end or lateral suture is to be made. Whenever possible, a pad of mesentery, omentum, or fat should be used as a patch over the sutured viscus. If there is any doubt as to the closure, it is a good plan to attach the involved portion of gut to the abdominal wall so that an external fistula may form if union fails to persist. It often happens that the perforations are far removed from each other, and this occurs especially in wounds transmitted from side to side, and before backward. With this in view, each foot of intestine must be separately investigated before the surgeon is satisfied that all holes are

located. If several are found within a short distance of each other, and if the lumen is likely to be encroached upon by the necessary multiple suturing, it is safer and quicker to resort to immediate anastomosis. The same applies if there is perforation and at the same time wounding of a leaf of the adjacent mesentery. Anastomosis is the usual resort in injury to a main mesenteric vessel, and then the amount to be resected may reach many feet. In these gastro-intestinal perforations, foreign matter should be removed by sponging and irrigation; and if much has been spilled, it is safest to make a suprapubic or supra-inguinal drainage opening for rubber tubing or cigarette drainage. Large quantities of food may often be found in the pelvic or other dependent portions, and at times some of the menu may prove temporarily confusing. I recall that tomato soup escaping from a posterior gastric opening once made me seek for a bleeding point at first; likewise segments of recently ingested sphagetti simulated bundles of roundworms.

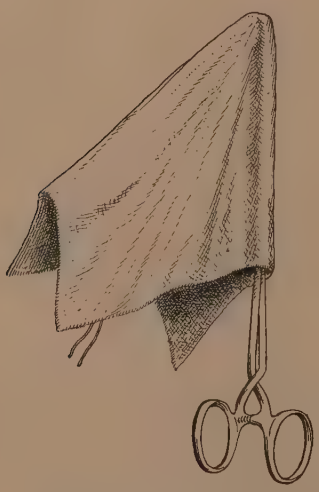


Fig. 483.—Mikulicz drainage and packing. Into this tent of gauze smaller pieces of gauze are fitted until the entire cavity is filled; this is sometimes called "the handkerchief drain."

Liver involvement leads to continuous but slow hemorrhage usually, although in some cases spontaneous arrest of bleeding may occur, especially if the wound is in the dome, where it undergoes pressure with the formation of a subdiaphragmatic clot. This organ has a tendency to split or crack in a more or less stellate manner and much bile usually escapes. In cases associated with extensive injury and bleeding, Mikulicz packing (Fig. 483) is the best procedure, together with attempts to forcibly crowd the organ against the diaphragm. Less severe cases may be deeply and widely stitched by the method shown in Fig. 484.

In a friable liver such suturing may fail to hold unless reinforced as indicated. Various schemes have been tried and several clamps have been devised to control portal circulation preparatory to suture, but these as yet are not very practical. Contusions over the liver occasionally cause soreness and pain on deep breathing and pressure, with a fine crepitus; these symptoms are supposed to be due to irritation

of the surface of the organ resulting in so-called perihepatitis. Many of these cases more properly fall into the pleurisy class, subdiaphragmatic in type ordinarily. They respond quickly to adhesive plaster strapping.

Gall-bladder involvement is occasional. I recall one case in which it had been displaced from position and dangled by its neck, leaving a bleeding surface to show its former attachment, and there was also a laceration on the right lobe of the liver. The patient was a youth who had struck his right upper abdomen while coasting. I operated for

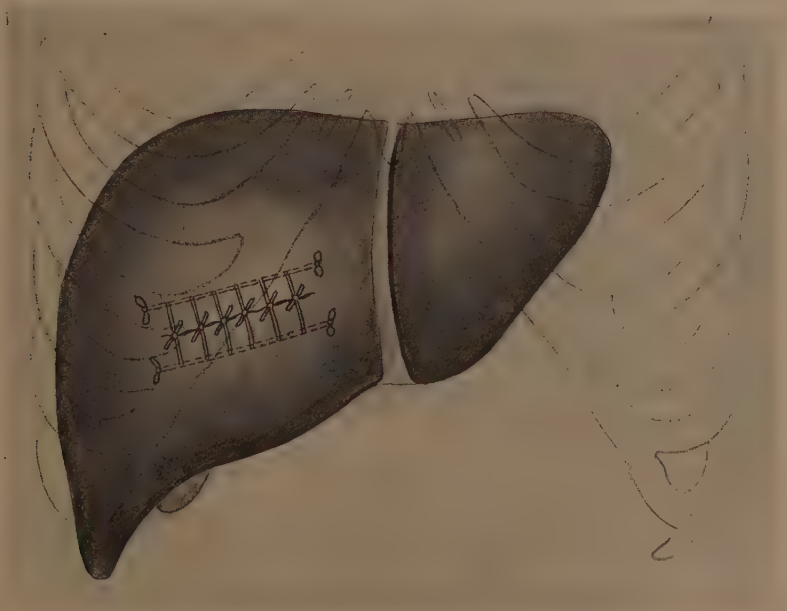


Fig. 484.—Laceration of liver, showing method of suture.

suspected ruptured liver based on localized pain, some discoloration, marked rigidity, and signs of intra-abdominal bleeding (pallor, thirst, weak, rapid pulse, and falling blood-pressure). The prolapsed viscus was stitched into place, the bleeding ceased, and prompt recovery followed.

Kidney damage may take the form of contusion, laceration, or perforation (Fig. 485). Blood in the urine is a regular symptom, together with pain, tenderness, and rigidity in the costovertebral region and over the abdominal surface of the organ. Frequently much perirenal bleeding occurs, and a mass can be made out on palpation and occasionally the bulging may be visible. Several cases have been recorded in which the bleeding has at first been so slight or slow that palpatory evidences

of it were lacking until distention of the kidney capsule and the perirenal space made it suddenly apparent. A case of this sort came under my care where a girl of fourteen sledded against an iron fence so that her right loin and abdomen struck forcibly against a post. She was stunned and immediately vomited, but was soon well enough to watch the others coasting and she did not go home for two hours. Then, on urinating, blood was noted by her mother and the family physician was summoned. He found no evidence of injury and she seemed not to have suffered any damage to her internal organs. Next day she voided blood frequently, but otherwise seemed well. On the third day

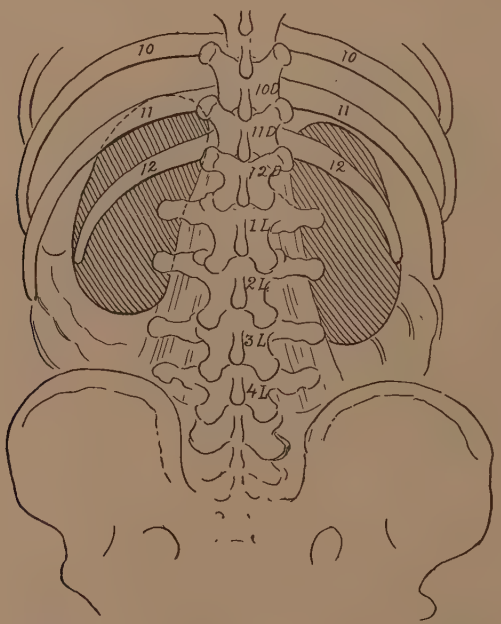


Fig. 485.—Normal site of the kidneys in relation to the ribs and vertebræ.

she complained of severe abdominal pains and an area of ecchymosis was noted above the iliac crest and she also passed blood at stool. That night she came to Harlem Hospital, but no localizing symptoms were noted by the house surgeon and her condition was not regarded as urgent. The following day (the fourth after the accident) I saw her, and then the right half of the upper abdomen was filled by a hard mass, but she was little disturbed by it and had to be awakened to permit the examination. That night her condition had grown worse and signs of intra-abdominal hemorrhage were present. Incision was made through the outer side of the rectus muscle, suspecting intes-

tinal as well as kidney injury, and immediately a walled-off retroperitoneal massive hemorrhage was encountered and an extraperitoneal nephrectomy was done. The kidney had been almost bisected in its transverse diameter and finally the clot had apparently burst through the original lines of cleavage, thus accounting for the gradual onset and sudden increase of symptoms. She recovered.

The lumbar approach is always preferable, and even when the organ is extensively damaged, suturing will often control the bleeding and preserve the organ. If the conditions permit, the surgeon should first satisfy himself that the opposite kidney functionates before attacking the damaged organ. In stab and bullet wounds the method of approach (lumbar or abdominal) will depend upon associated visceral injury; the organ should be reached through the back when feasible, otherwise by the extraperitoneal abdominal route (Fig. 486). Furious and rapidly fatal hemorrhage occurs from perforations involving the region of the kidney pelvis, and here the surgeon usually operates, with a tentative diagnosis of intra-abdominal bleeding, through the outer border of the rectus muscle.

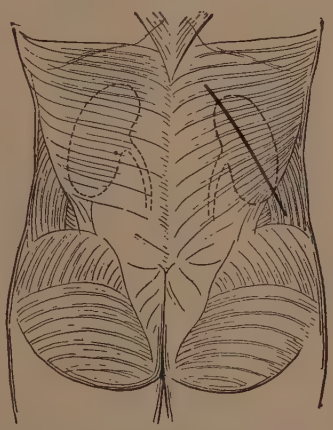


Fig. 486.—Oblique lumbar incision for approach to the kidney.

The presence of hematuria and localized pain alone does not warrant operation, as contusions and small lacerations usually spontaneously recover. I have never known a case of this sort to develop a true nephritis subsequently.

The *indications for operation* are progressive signs of hemorrhage, and, as has been stated, interference may be demanded at once or be delayed until a mass appears or systemic signs of bleeding present. In all these cases the use of urotropin or other urinary antiseptics is advisable.

Spleen injuries ordinarily bleed very promptly and excessively, especially if the hilum is involved. This is notably true if the organ has previously been enlarged, as by malaria, anemia, or from splenomegaly of any variety. Contusions cannot be diagnosed in the absence of actual inspection, and then more or less laceration is generally found. Run-over accidents are very common causes of this injury, and it has been said that wheels passing from right to left over the upper abdomen more commonly damage the liver, the spleen being

more likely to suffer when the wheels pass from left to right. Perforations from bullets and stabs are usually sources of enough damage to call for splenectomy, inasmuch as it is exceedingly difficult to suture the injured organ; occasionally gauze packing checks the bleeding. These patients survive the removal of the organ splendidly, and apparently no permanent ill effects follow, as other hemogenetic organs vicariously carry on splenic functions.

Pancreas injuries are generally associated with those of the stomach and offer no special diagnostic or treatment differences. A leaking pancreas is a foe to union of an operative wound, and for that reason drainage should be more plentifully provided than in any other organ. It has been stated that the postoperative wound of the late President McKinley was extensively necrosed from pancreatic secretion despite ample drainage.

Bladder contusions are relatively common and occasionally lead to cystitis after active hematuria ceases. Laceration, rupture, and perforation each require suprapubic exposure, and if the wound is linear and not too extensive, it is to be closed by purse-string or tier suture, drainage being made of the suprapubic space. If the wound is ragged or large, a rubber tube is sewed into the orifice and brought out through the abdominal wound to provide drainage after the manner of a suprapubic cystotomy. After a week or less it can be wholly withdrawn or a smaller tube inserted. This organ responds well after injury and it is probably perforated at operations more frequently than any other hollow viscus.

Generative organs are very rarely affected, due to their protected position. I recall but one case in which the uterus was damaged, and that was in advanced pregnancy due to a fall astride a chair. Death followed from extensive hemorrhage associated with laceration of the perineum, margins of vagina, cervix, and uterine wall.

Injuries of the Genitals

Injury of the Penis

Contusions and **wounds** may occur from blows, falls, missiles, bullets, knives, and various other sources. This organ is often the object of attack in the insane and revengeful. The effects vary somewhat, depending upon the flaccid or erect condition.

Contusions present the ordinary signs of swelling, pain, much ecchymosis, and, usually, urethral bleeding. Priapism may be associated. Phimosis or paraphimosis may result if the swelling or edema

is excessive. This form of engorgement occasionally occurs in children or others when the part is constricted, as by a ring or other encircling band. Negroes are said to gain revenge by a process of constriction of this sort which they term "point tying," and gangrene may be induced thereby.

Treatment.—In the minor forms this is by hot or cold lotions, like salt solution or lead and opium. In the severer forms, where contusion or rupture of the urethra exists or is suspected, it is wiser to also introduce a soft-rubber catheter and permit it to remain as long as necessary.

Phimosis and paraphimosis is relieved by linear incision or circumcision if reduction cannot be effected by the method shown in Fig. 487.

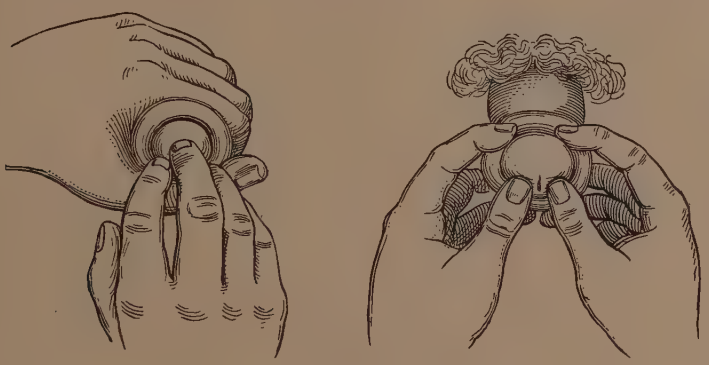


Fig. 487.—Reduction of a paraphimosis.

Wounds, especially of the dorsum, bleed freely if deep or if the dorsal vessels are involved. If the corporæ are involved, much gaping may occur.

I recall a Harlem Hospital patient in which the organ had been amputated completely at the pubis by a razor in the hands of a jealous mistress, and the bleeding then almost resulted fatally. Later I sutured the urethral orifice to the margin of the skin and subsequently the patient voided normally. To restore some semblance of the former reality, I proposed to transplant the appendix to the urethral stump and thus obtain a hollow tube to which I might subsequently graft skin and fat. The patient refused this because he could not be assured of erectile power as well.

Where the **urethra** has been involved, efforts at first should be made to introduce a catheter. Failing this, perineal or suprapubic drainage of the bladder should be provided until conditions permit repair of the urethra (Figs. 488, 489). Urethroscopic search may be

found valuable. Extensive wounds should not be regarded as an indication for amputation, as the reparative capacity is very great.

Fracture occurs occasionally from blows or twists when the organ is erect (as in chordee), and the symptoms resemble severe contusions with or without damage to the urethra, with also the presence of a more or less well-defined sulcus if seen before or after the swelling. In all instances of intra-urethral damage an end-result may be stricture unless dilatation is maintained by the frequent passage of sounds. Sexual

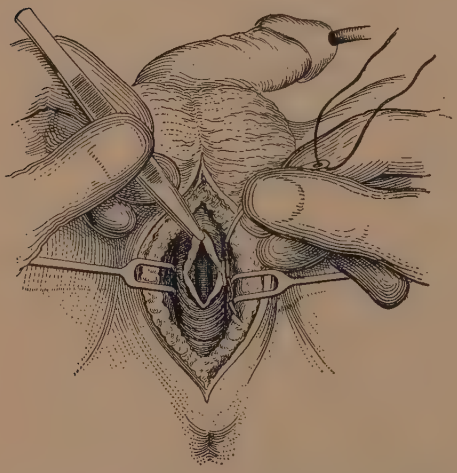


Fig. 488.—Rupture of the urethra (incomplete), showing catheter extending into bladder from meatus. Urethral wound being closed.

Fig. 489.—Rupture of urethra (complete), showing suprapubic and penile catheter introduced.

incapacity is not a likely sequence as the vascularity of the organ is so great that it readily recovers from even very considerable degrees of trauma.

SCROTUM INJURY

Contusions.—These may follow from blows, falls, or kicks. Children and others frequently sustain injury to this part at play by landing astride fences or posts.

Symptoms are nauseous or acute pain and swelling, with much ecchymosis that often extends to the abdomen, perineum, and thighs. If infection occurs, sloughing and signs of sepsis supervene.

Treatment.—This need be given to the severer forms only, as the milder grades spontaneously subside, although the ecchymosis may last weeks. Lotions, hot or cold, like lead and opium or saline solution, are applied and the part is kept elevated by a suspensory, or a **T** or "triangular" bandage, or by broad straps across the upper thighs.

If abscess, sloughing, or infection threatens, incision in the line of the rugæ is indicated, and then drainage is instituted with rubber or gutta-percha tissue. The skin of the scrotum does not well withstand antiseptics, and therefore only mild applications must be used so that no irritating dermatitis may arise.

Wounds may occur from stabs, bullets, missiles, nails, and other more or less pointed objects. Bleeding may be quite copious, and if the rent is great enough the scrotal contents may extrude or share in the damage. When the penetration is complete, hematoma of the cavity may coexist.

Treatment.—Suture and drainage is indicated and efforts should be made to coapt in a transverse rather than a vertical direction so that the normal rugeal lines may be followed. If this is possible, the scarring is often invisible after a short period. Drainage should never be omitted, and a few strands of catgut or a folded leaf of gutta-percha is often enough; the drain can ordinarily be removed at the end of twenty-four or forty-eight hours if by that time there is nothing but serous oozing.

Associated damage is discussed later.

TUNICA VAGINALIS AND SPERMATIC CORD INJURY

Contusions.—These may occur from any of the forms of violence previously mentioned, resulting in a collection of blood outside the tunica vaginalis (hematoma of scrotum) or inside the tunica vaginalis (hematocele); the former is by far the more usual.

Symptoms.—These resemble those of contusion of the scrotal wall plus a fluctuating, boggy, pear-shaped swelling beneath the testicle, not involving the latter in the extravaginal forms. The amount of blood may be very great.

The *hematocele* varieties generally occur where a hydrocele has previously existed, and most of them follow direct injury to the testicle when a hydrocele is being tapped.

The so-called *pathologic hematocele* is not due to injury, but is a spontaneous chronic hemorrhagic inflammation of the tunica vaginalis, generally occurring in rheumatics, arteriosclerotics, and old men. With this variety considerable thickening eventually occurs, and an initial diagnosis is often made of tumor of the testicle.

Treatment.—In the average hematoma, indications are met by elevation of the scrotum and cold applications or ice-bags for the first hours; later, elevation and some pressure generally brings about absorption and cure. In larger effusions, aspiration or perhaps incision

may be required; neither procedure should be undertaken until the acute symptoms subside, or the more usual methods of relief fail. Hemorrhage is practically always controlable by clot formation or pressure, without resort to operative search for bleeding sites.

Undue zeal in treatment will often work harm, as most of the cases spontaneously recover.

Hematocele generally requires operation to remove the blood; some cases of long standing require removal of the entire sac.

HYDROCELE

This is a collection of fluid within the tunica vaginalis. It may occur as an acute condition, but ordinarily is chronic.

Acute Forms.—*Causes.*—These are almost always sequential to gonorrhea, and may occur as an early or late complication of this

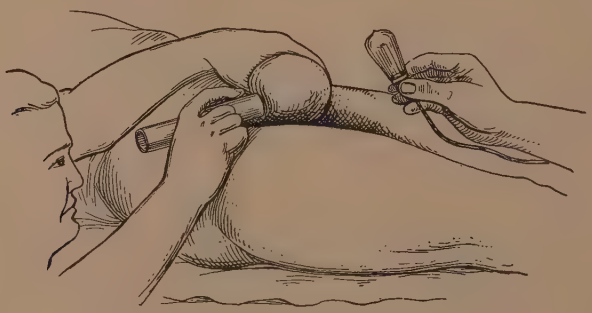


Fig. 490.—Transillumination of a hydrocele.

disease. It is less often secondary to typhoid, mumps, and other infectious diseases. Tuberculosis and syphilis are other sources. The epididymis or testicle, or both, are usually coincidently involved.

Injury may be causative where the violence has occasioned orchitis; it is, however, the rarest of all causes.

Symptoms.—A sudden painful, reddened, fluctuating, hot swelling appears that is translucent to reflected light (Fig. 490). The onset is usually febrile and there may be chills, nausea, and vomiting.

Treatment.—Elevation of the scrotum, hot moist dressings, and a cathartic are prescribed at first. Later, an ice-bag and some pressure may be used. In excessive swelling, with much pain and tension, aspiration or incision and drainage are best. If pus forms early, incision and drainage are imperative. Most cases subside quickly.

Chronic forms are by far the commonest, and ordinarily they exist

for years before the active attention of the patient or physician is called to them.

Symptoms.—Usually there is a history of a slightly painful enlargement of one-half of the scrotum that finally becomes big enough to attract attention because of inconvenience. The average patient suspects he is ruptured. This enlargement, on examination, may or may not fully fluctuate; and if it does not, a hernia may require differentiation. The spermatic cord will be found free and it can be followed up to the enlarged patent external ring. The swelling will be found translucent to reflected light.

Tumors of the testicle may be hard to differentiate, notably in very old hydroceles with thick sacs or when the contained fluid is viscid.

Hydrocele of the cord is generally found in infants and the young, and the differentiation from hernia is then often more difficult.

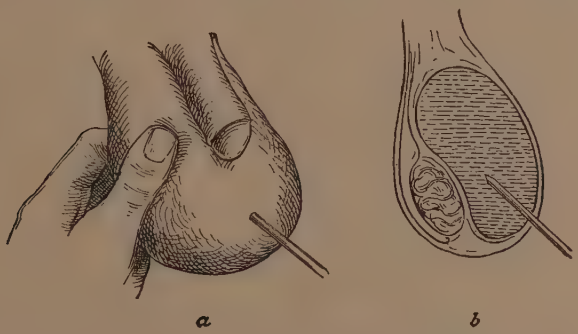


Fig. 491.—Aspirating a hydrocele: *a*, Site of external puncture; *b*, sac in relation to testicle.

Hydrocele bilocularis is relatively rare, and the findings here are practically those of a series of cysts.

Abdominal and *hour-glass hydroceles* are rarer forms, and these may occur at any age, but are common in infants and children. *Injury* is the ascribed cause in a large proportion of cases, but is rarely the true source. *Gonorrhea* is a frequent factor. *Tuberculosis, syphilis, typhoid,* and other infections are also causative.

Treatment.—In most hydroceles, palliative measures, such as ointments, iodin, and other applications, generally avail but little, although for a time the progress may appear to be slow or even show recession.

Operative measures consist of (1) *Aspiration:* A hollow needle is introduced and the fluid drained (as in Fig. 491). Recurrence is the rule within two or more weeks.

(2) *Aspiration and injection:* After the fluid has drained away, from 5 to 30 drops of pure carbolic acid is injected into the cavity through

the canula from which the fluid has escaped. This is done slowly, and then the canula is withdrawn carefully so that none of the carbolic gets into the scrotal wall. Then the scrotum is massaged for five minutes and the patient is sent to bed, an ice-bag is applied, and the scrotum elevated. Pain is present for several hours and the fluid reaccumulates, but subsides in a few weeks. The patient is allowed to get up a day or two after the injection. Tincture of iodin is also used in the same manner. In cases of recent origin, where the sac is not too thick, it is stated that from 70 to 80 per cent. of patients are cured by this form of treatment.

(3) *Incision of the sac:* The sac is opened and turned inside out and sutured about the cord and testicle (Jaboulay's operation). Or a small split is made at the upper part of the sac and the testicle squeezed through this, and then the sac is allowed to remain behind the testicle, no sutures being required (Andrews' "bottle operation"). Any of the foregoing can be done under local anesthesia.

The injection methods answer well for children and early cases.

INJURY OF THE TESTICLE

Contusions occur from kicks, falls, blows, and other direct forms of violence; very rarely some great muscular effort or straining is responsible.

Symptoms.—Nauseous pain and variable degrees of shock are the initial signs; in some cases vomiting and unconsciousness have occurred. Soon, swelling and tenderness appear and there is extravasation of blood, visible on the scrotum and usually palpable within the tunica vaginalis and along the epididymis. In other words, the combined signs and symptoms of orchitis, contusion of the scrotum, and hematocele exist.

Treatment.—Elevation and hot applications at first are useful; later cold and a suspensory bandage may be more agreeable.

If *abscess* forms (this is rare) incision and drainage will be needed.

Torsion and *dislocation* are very rare, and the symptoms and treatment are similar to contusion of the part.

Wounds may occur from stabs, bullets, or impaling accidents. Bleeding is likely to be severe, and hematoma of the scrotum or hematocele may occur.

Treatment.—Cold applications, elevation, and pressure are used for the ordinary cases, with suitable suture and drainage. If the bleeding is excessive, the wound of entrance will need exploring so that the source of hemorrhage may be located.

The *outcome* of traumatic orchitis is generally favorable, and the function of the testicle is rarely permanently affected unless abscess occurs, or there has been excessiv e formation of fibrous tissue with considerable alteration in size and consistency.

INJURY OF THE SEMINAL VESICLES AND PROSTATE

These are so protected that they are never injured except there has been associated damage, like fracture of the pelvis or severe lacerations. Infection of the genito-urinary tract is the usual source of trouble.

INJURY OF THE VAGINA

Contusions from kicks, falls, or missiles result in swelling and ecchymosis of the labiæ, and the ensuing discoloration may extend to the perineum, abdomen, and thighs. Definite hematoma formation is common. Dysuria from swelling may be bothersome. Rectal and urethral bleeding may be associated. Children are likely to show excessive edema, and excoriation from urine may produce troublesome eczematous conditions. Multiparæ apparently withstand this sort of violence better than others.

Treatment.—Cold applications or soothing lotions answer for the ordinary cases. Hematomas may need incision if external treatment is ineffective after a reasonable time. The ecchymosis may persist for weeks.

Wounds may occur from stabs, impalement, or pointed tools or missiles. The *hymen*, torn at intercourse or by other violence, occasionally bleeds excessively; otherwise the injury is unimportant.

The perineum or vaginal walls may share in the tearing, and I have seen cases where the wound even extended therefrom beyond the margins of the cervix, due to a fall astride an object. Bleeding may be quite marked and there is generally considerable swelling and discomfort, with marked systemic shock.

Treatment.—Suture and drainage will be needed if the bleeding is great; usually control by packing will take the place of immediate suture. Hymen tears require ligation of the spurting vessel that usually comes readily into view. Injuries to these parts very rarely result in lasting pelvic disturbance.

CHAPTER XV

INJURIES OF THE NERVES, BLOOD-VESSELS, AND LYMPH-VESSELS

Injuries of the Nerves

Individual nerve-fibers or trunks may be damaged by a variety of direct and indirect forms of violence, usually as accompaniments of other injuries.

Neuritis and Perineuritis

Inflammation of the nerve-fiber (neuritis), or of the nerve-sheath (perineuritis) may arise from *direct* injury to the nerve, as from wounds, blows, falls, and compression; or from *indirect* injury due to stretching or traction.

A "traumatic neuritis" is always a "localized" or "simple" neuritis, and is limited to one set of nerve-fibers or a plexus, and is never a "multiple" neuritis or "polyneuritis" which is always toxic in origin (as from alcohol, lead, rheumatism, fevers, infections, etc.).

Nerve inflammation from injury is very exceptionally of the ascending variety, and extension to the spinal cord practically never occurs from a distant focus; thus myelitis from such an origin is a clinical rarity.

Symptoms.—The nature, origin, and site of the lesion determines the manifestations, but in all cases—

(1) *Pain* is the chief sign, and this is limited to the course and distribution of the nerve, and in character may be sharp, stinging, burning, boring, shooting, or numbing.

(2) *Tenderness* along the course of the nerve is also present.

(3) *Swelling*, *redness*, and *local heat* may also occur.

(4) *Pain on motion* exists.

(5) *Diminished* or *increased* sensation appears.

(6) *Paresthetic signs* may occur, like tingling, "pins and needles," and crawling sensations.

Inasmuch as mixed nerves are generally involved in accidents, *motor manifestations* are also present, such as—

(7) *Weakness* or *paralysis* of muscles innervated by the involved nerve.

(8) *Twitching* or *spasms* may also occur.

(9) *Trophic manifestations* are always present in continued or marked cases, and then

(10) *Atrophy* is the chief feature, and still later *contractures* may occur. In advanced cases trophic changes are seen also in the *nails*, *skin*, and *hair*, so that their texture is markedly altered and the part looks glossy or thickened and roughened and the surface temperature is changed.

(11) *Ulceration* and *gangrene* appear in some cases and trophic ulcers form.

(12) The *reaction of degeneration* is present in cases showing many objective evidences.

(13) *Changes in the reflexes* occur in marked cases (Fig. 492).

Fig. 492.—Plantar reflex: *a*, Normal; *b*, Babinski.

Manifestly all grades are encountered, from the transient "pins and needles" sensation of an ulnar neuritis from striking the "funny bone," to the total wasting of an upper extremity from avulsion of the brachial plexus.

The commonest clinical forms affect the upper extremity involving the brachial plexus or some of its branches, notably the musculospiral, median, or ulnar nerves.

In the lower extremity the sciatic, popliteal, and tibial nerves are most commonly affected.

Direct damage from *wounds* causes the most typical cases, together with those arising from *compression* by bone (as in dislocations and fractures), foreign bodies, or external pressure (occupational; "crutch paralysis"; or tight bandaging).

In every instance it is important to recognize that trauma produces *localized* or *regional* involvement and that the multiple and generalized forms are due to constitutional causes. Occasionally sepsis may be an inducing cause of a multiple neuritis, but this is clinically very rare.

The rate of progress from the onset of pain to the development of atrophy is variable, but is reasonably prompt, as traumatic cases are of the *acute* type, and within a fortnight there is ordinarily some obvious difference in size and texture in the involved part, especially if immobilization has been employed.

Treatment.—This practically resolves itself into removing the source of trouble. Divided nerves are sutured if possible; pressure is removed where that element is at fault.

Pain is relieved by external applications of heat or cold or the use of anodynes. Placing the part at rest by a splint or suitable dressing and elevation are essentials of treatment.

The more resistant cases are subjected to *counterirritation* by iodin or other drugs of that class; electricity, vibration, blistering, or the actual cautery may be tried. In still more resistant cases, forcible stretching, especially in sciatica, is very efficient. The injection of the nerve-sheath by sterile water or alcohol is also occasionally needed. Sedatives by mouth should be used cautiously so that no habit is induced.

Atrophy is overcome by massage and forced use, and these measures persisted in will prevent or overcome contractures or deformities.

Constitutional diseases, notably rheumatism, gout, and syphilis, if coexistent, must be suitably treated.

In persistent cases, and where prompt response does not follow the use of ordinary measures, resort should be to mercury and the iodids, even in the presence of a negative luetic history.

Neuritis of Individual Nerves

Damage to a single nerve or plexus may arise from (*a*) *Contusion*, (*b*) *stretching*, (*c*) *laceration*.

(*a*) **Contusion of Nerves.**—This may occur from blows or falls and thus produce the effects at once; or the onset may be deferred and follow slowly increasing or persistent *compression*, such as may be induced by callus, organized exudate, scars, or apparatus like bandages, splints, or crutches.

Symptoms.—Mild cases manifest pain, tingling, and numbness with more or less paresthesia, with perhaps local heat and the

accompanying signs of contusion. Tenderness on pressure along the nerve pathway usually coexists.

Moderate cases manifest the above with more or less well-marked muscular paralysis, the motor signs generally being more marked and persistent than the sensory. After the paralysis has persisted a week or more, atrophy usually appears and the shrinkage progressively becomes more apparent the longer the condition persists, and in time the atrophy may appear also in the involved or adjacent joints and bones. Trophic manifestations are usually absent unless the lesion has lasted a long time.

Severe cases are exaggerations of the preceding and the reaction of degeneration is often present, and in effect the symptoms are those of laceration.

Treatment.—Contusion forms are treated by rest (with or without well-padded splintage) and anodyne lotions, such as hot or cold lead and opium, alcohol and water, salt solution, or aluminum acetate (4 per cent.). After the pain and local tenderness subside, massage and electricity effectively promote the return of function.

Compression forms demand removal of the originating cause such as callus, spiculæ, bandages, splints, apparatus, crutches, etc.

In this connection it is pertinent to again say that no encircling or constricting dressing or apparatus should ever be applied to an acutely inflamed or swollen area, notably the forearm and leg.

Early recognition is the main element of successful treatment. If callus is at fault, operation should be undertaken; practically this is demanded only in musculospiral involvement following fractured humerus. Very exceptionally nerves may be pinched in scars of the soft parts, as in amputation stumps or deep adherent scars, and here also operative release is required.

The *outcome* is usually excellent and perfect restoration of function is the rule. Compression from callus offers the poorest prospect, but even after many months a happy result has often followed surgical measures.

(*b*) **Stretching of Nerves.**—This form is limited practically to the region of the shoulder (brachial plexus), neck (cervical plexus), and hip (sacral plexus), and the manifestations are generally associates of dislocations or fractures. The main damage is to the sheath of the nerve and to the peripheral rather than to the central fibers. The lesions produced, according to Woolsey (Keen's *Surgery*, Vol. II), are: (1) Loosening of the sheath; (2) narrowing of the sheath and constriction of the contained fibers; (3) partial tearing of the blood-vessels of the

sheath, causing ecchymosis; (4) tearing of more or less of the nerve-fibers, resulting in degeneration.

Symptoms.—Mild and moderately severe cases are similar to contusions; severe cases resemble lacerations.

In the case of a stretched sciatic, the opposite nerve may also be affected at the same time, but ordinarily not to the same extent. It is to be recalled that nerve stretching is a method of treatment in sciatic neuritis, and thus neuritis of this plexus rarely if ever follows indirect violence.

Treatment.—Rest is the main element, the part being so placed that tension is relieved. External applications (as in contused nerves) may also be helpful. Later, massage, electricity, and increasing use are advisable.

The *outcome* is generally excellent unless avulsion has occurred, and then the prognosis is that of lacerated nerves.

(*c*) **Laceration of Nerves.**—This follows wounds and penetrations from without, but may also be rarely due to fractured ends of bone. The most typical cases are accompaniments of deep lacerated wounds.

Mild grades, in which only the sheath of the nerve or some of the fibers are cut, give symptoms similar to contused or stretched nerves. The sensory signs are generally least marked because adjacent sensory fibers form so close an anastomosis. In cases seen after the wound has been partially or wholly closed, and where it is small, or if swelling or inflammation are present, the onset of nerve disturbance may not be noted until the local signs become marked enough to produce atrophy or paralysis.

Moderate grades show aggravated signs of the preceding, with minor trophic changes; existing hyperesthesia is proof positive of at least partial severance.

Severe grades indicate total severance of the involved nerve, usually with more or less retraction of its ends. The onset of symptoms is usually immediate and *paralysis* is complete as the muscles are no longer innervated. *Sensory changes* are coincident and the patient usually is aware of the existing *anesthesia*, and this is associated with loss of sense of touch and heat and cold in corresponding areas.

Atrophy is prompt and contractures and other *deformities* rapidly occur unless the part is suitably splinted or provided with apparatus to prevent the action of unantagonized muscles.

Trophic changes show early, and the part is at first red and swollen, and later dry, glazed, and cyanotic, and finally ulceration may occur from pressure or malnutrition.

Electric irritability diminishes, so that in from two to seven days muscular contraction to *faradic* irritation disappears. Response to galvanic irritation becomes slight within the first few weeks and is usually lost after six weeks.

This loss of response to electric excitation constitutes the *reaction of degeneration*, and this is made up of a *quantitative* and a *qualitative* form of response. Normally the contraction obtained by closure of the negative pole is greater than that obtained by closure of the positive pole; this is expressed by ACC<KCC. In the presence of degeneration this formula becomes ACC>KCC, or ACC=KCC. This test is extremely valuable and reliable if properly and carefully made by a trained observer; otherwise it is the reverse. To be of proved value the other clinical evidences of wholly deficient innervation must also exist (*i. e.*, paralysis, atrophy, anesthesia, and trophic signs).

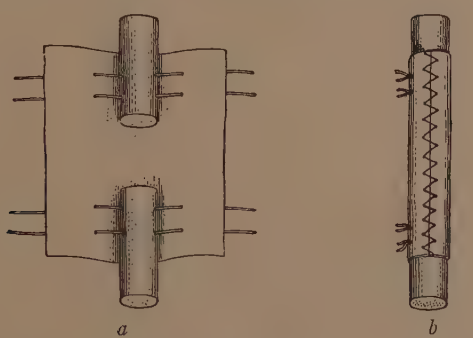


Fig. 493.—Treatment of a severed nerve by enclosing it in fascia obtained from an adjacent or distant source (as the fascia lata): *a*, Fascial envelope prepared; *b*, nerve enclosed in fascia.

After the nerve has united, it may be many months (one to twelve) before electric excitation returns to normal, even in the presence of restored muscular, sensory, and trophic functions; for this reason the test is of greater diagnostic than prognostic value. Ordinarily faradic precedes galvanic return.

Treatment.—Mild grades are treated like contused nerves. When the fibers are actually separated (moderate and severe grades) they are best treated by immediate suture (neurorrhaphy), the effort being to coapt the shreds by silk or gut sutures so that no tension occurs after union. With this in view, various operations have been devised to lengthen the fibers by so stretching or so splitting them that the anastomosis becomes quite perfect. The line of junction should then be encased in a blood-vessel or a pad of fat or fascia taken from an

adjacent source, so that added strength and freedom from adhesions may be gained (Fig. 493). If retraction is too great to be overcome by

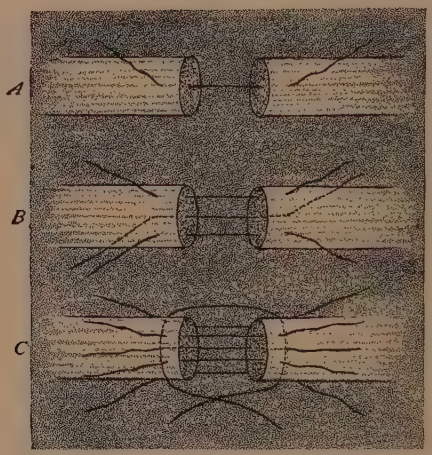


Fig. 494.—Nerve suturing methods: *A*, Single suture; *B*, triple suture; *C*, multiple suture.

splitting, then a tendril of another nerve or silk or fascia unites and bridges the severed ends and acts as a trellis. These procedures are

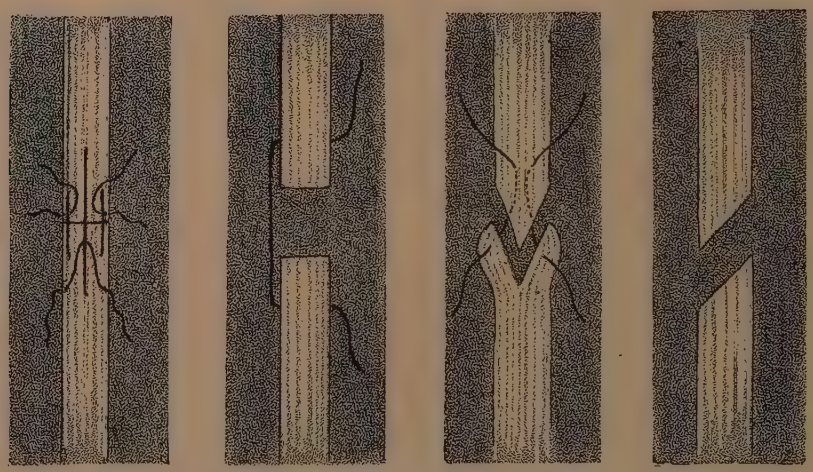


Fig. 495.—Nerve suturing methods.

suitably indicated by Figs. 494 and 495. Primary union is to be sought; but even in the presence of infection, the nerve-ends should be coapted as far as possible, if only for identification purposes. When

retraction is too great to be overcome, or where failure of union has occured, recourse is to (1) anastomosis with adjacent nerves; (2)

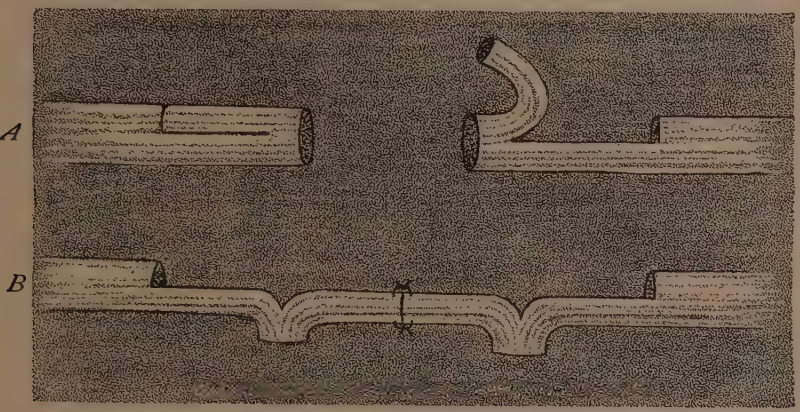


Fig. 496.—Nerve lengthening and anastomosis: *A*, Lines of incisions; *B*, junction completed.

intervention of a section of vein or fascia into the lumen of which the nerve-ends are stitched; (3) resection of bone.

Where infection prevents union, secondary suture may be employed after the bulbous or sloughed ends have been excised.

Fig. 497.—Nerve anastomosis.

Functional return after suture is aided by electricity (first galvanic and then faradic), massage, and gradual usage of the part.

The *outcome* is good if early complete suture can be made. Return of function is first seen in restoration of sensation and disappearance of

atrophy, the motor return often being long delayed, and it may not fully return for years in advanced cases. Sensory and trophic improvement may be noted within a few hours, but motion does not generally show any return short of two weeks.

Horsley advised waiting eighteen months before resorting to secondary suture after an initial suture with primary union, when improvement becomes stationary or retrogression sets in (Keen's *Surgery*). If improvement, however, continues, hope must not be abandoned, as recovery may require more than two or three years.

Injury of Special Nerves

The injuries affecting most of the cranial nerves are included ordinarily in the symptoms of intracranial injury, notably fractured base of the skull.

However, some of these nerves are occasionally damaged by extracranial trauma, notably the fifth, seventh, eighth, ninth, tenth, and eleventh.

Fifth Cranial Nerve (Trigeminus).—As will be recalled, this mixed nerve has six branches distributed to the region of the eyebrow, cheek, and lips, and damage is usually to one of the branches, generally from a localized blow or wound, and less often from fracture of the jaw. The *supra-orbital* branch is oftenest involved, as in wounds of the eyebrow (Fig. 498).

The *symptoms* common to all branches are *pain* or *anesthesia*, or both, corresponding to the distribution of the branch affected.

Treatment.—This is for the associated injury.

Prognosis is usually good, as the part rapidly becomes re-innervated, as will be recalled on mention of the difficulty in preventing resumption of function when the nerve is deliberately damaged in an attempt to cure neuralgia from this source.

Tic douloureux is never traumatic in origin except in so far as dental caries or tumor formation may in turn be traced to an injury.

Seventh Cranial or Facial Nerve.—As already stated, this nerve is more commonly injured than all others in *intracranial* injuries, notably fractured base of the skull. *Extracranial* causes are blows in the region of the ear or parotid, wounds, and fracture of the jaw or malar bone. Operations about the angle of the jaw, neck, and mastoid regions are also frequent sources of origin. Peripheral involvement is known as "Bell's palsy." The commonest extracranial sources of origin are exposure to drafts and changes in temperature, and from infections, rheumatic or otherwise.

The types depend on the location of the lesion, as the nerve may be affected within or without the brain. Thus it may have a *central* or *supranuclear* involvement from a lesion of the cortical fibers en route to the nucleus; this is an associate of apoplexy (hemiplegia), as a rule, and is not traumatic. Figure 499 indicates the possible sites of external involvement.

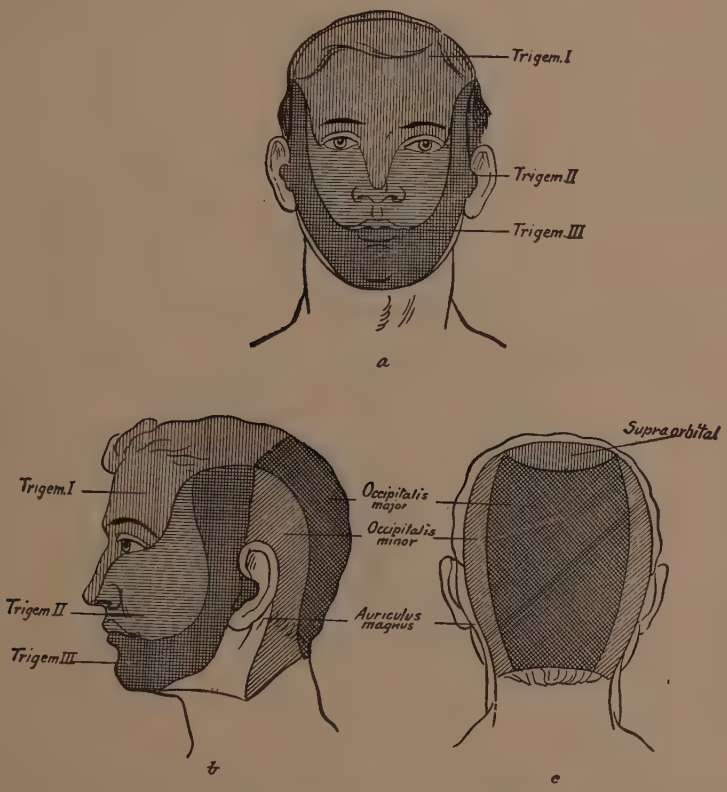


Fig. 498.—Superficial sensory nerve-supply of face and scalp: *a*, Front of face; *b*, side of face and scalp; *c*, back of scalp.

Nuclear involvement is also non-traumatic, and is the outcome of cerebral hemorrhage, embolism, softening, and some infections (like poliomyelitis and diphtheria).

A special form of this type of involvement is known as *crossed paralysis*, in which the face is involved on the side of the lesion, and the arm and leg on the opposite side. Here the lower part of the pons is involved, as in certain types of fractured skull and intracerebral hemorrhage.

At the *exit from the pons* involvement may occur from a variety of

non-traumatic causes, notably tumors and syphilis, but lesions here always affect other cranial nerves coincidently (Dana).

During the *course through the bony canal* (aqueduct of Fallopius) involvement may and often does occur from damage to the petrous portion of the temporal bone in fractured skull; otitis media is a very common originating factor in this zone.

At or after *emerging from the stylomastoid foramen* it may be affected by contusions or wounds, and occasionally by fractures or dislocations of the jaw or other sources of pressure.

Thus it is seen that the *central* types are often non-traumatic, and the *peripheral* types are traumatic or due to cold or infection.

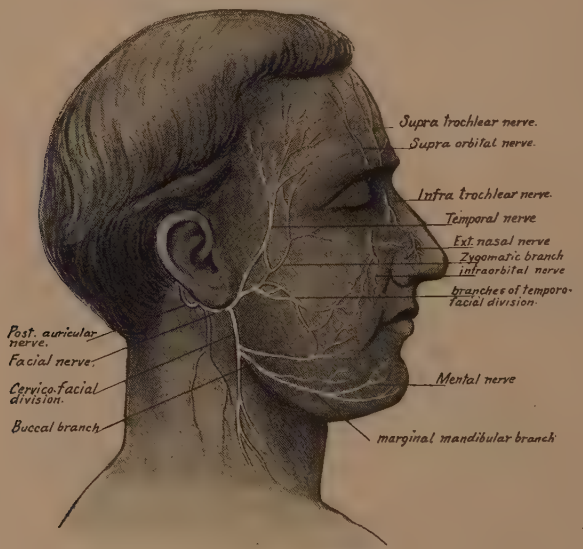


Fig. 499.—Facial nerve and its distribution.

Symptoms.—These depend on the site and extent of the lesion, but a typical case will very promptly show a flattened, wrinkleless cheek, drawn to the sound side by the unopposed facial muscles. The eye cannot be closed and tears may flow freely and a conjunctivitis often exists. The forehead cannot be wrinkled, or the affected cheek puffed out, or the tongue protruded in a straight line. Efforts at laughing, whistling, or grimacing pull the face toward the good side.

If the *temporofacial* branch alone is affected, the forehead and eye only are involved; if the *cervicofacial* portion, the lips, cheeks, and platysma are inactive.

In some cases the eighth (auditory) nerve may show associated involvement as indicated by tinnitus aurium and vertigo; but this

nerve is the only one coincidently affected in peripheral facial involvement (Bailey). Taste is occasionally affected on the anterior two-thirds of the tongue on the paralyzed side, but this symptom is usually unknown to the patient and only exists in deep-seated lesions within the Fallopian canal where the chorda tympani joins the facial. Paralysis of the stapedius causing tension of the drum membrane may also be associated, and this produces hyperacuity of hearing.

Sensation is intact on the face, but may be somewhat altered behind the ear. In paralysis of long duration stiffness of the side of the face may occur, and later atrophy and contracture may appear. *Electric excitability* is altered and cases of even moderate severity may show a partial reaction of degeneration. In such cases galvanic contraction becomes normal within two months, and soon after that faradic contractility returns, and recovery is generally complete in a fairly well-developed case in three months. In severer cases the reaction of degeneration may persist for a year and yet recovery may occur. Remak, quoted by Starr, refers to a case of recovery after three years of paralysis.

Prognosis.—This depends on the site and extent of the lesion. Complete severence, as from an accidental or operative wound, will not be followed by recovery unless nerve anastomosis is performed. Involvement due to a fractured base of the skull is generally recovered from. Cases of partial involvement quite uniformly get well. The outcome and initial severity are both determined with greatest accuracy by the electric responses.

Treatment.—This is usually directed to the associated injuries; but after recovery from these, resort may be had to massage, electricity, and strychnin. Nerve anastomosis with the hypoglossal or spinal accessory is reserved for cases of facial severance or where other forms of treatment have proved ineffective. Cases have been cured by anastomosis after lasting twenty-nine and one-half years (Elsberg).

Eighth Cranial Nerve (Auditory).—This is rarely involved alone, but it is often affected in conjunction with the facial nerve.

There are two divisions of this nerve, the *cochlear* part having to do with hearing, and the *vestibular* part having to do with the maintenance of equilibrium.

Causes.—Intracerebral injury, like fractured base of the skull or basal hemorrhage, is practically the only traumatic source. Congenital and acquired causes of deafness are, of course, numerous, and these must be excluded, especially in those instances in which the facial nerve is not coincidently involved.

Middle-ear disease and other infections are the usual factors in deafness.

Symptoms.—Deafness, tinnitus, and vertigo are usually associated and are of all degrees. Normally, tuning-fork vibrations are heard longer and better through the air (air conduction) than through contact with bone (bone conduction). In middle-ear disease associated with deafness the vibrations are heard through bone, but not when in contact with the ear. In auditory nerve deafness the reverse pertains, so that sounds are best heard when close to the ear, and here higher-pitched notes are less well heard than low notes, and hearing is not increased in noisy places as it is in middle-ear disease, nor does inflation of the eustachian tube cause improvement.

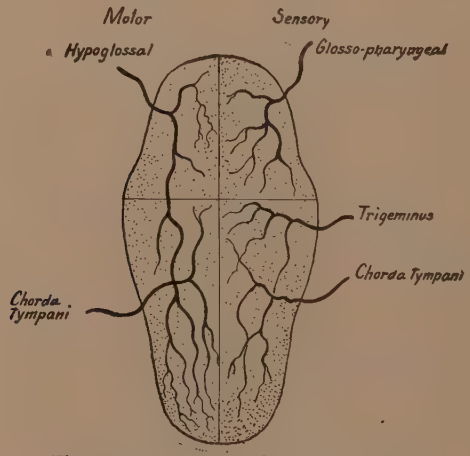


Fig. 500.—Nerve supply of the tongue.

Prognosis.—If the laceration of the drum has healed kindly, the outlook is better than if otitis has followed or preceded.

The grade of involvement may sometimes be determined with fair accuracy by electric tests applied to the coincidently affected facial nerve.

Fracture of the base of the skull, with deafness that does not improve as fast as a coincident facial palsy, is likely to result in permanent impairment of hearing to some degree.

Generally speaking, the outlook is not as good as it is for facial involvement. Most cases show improvement within the first few weeks, and cases lasting beyond six months rarely completely regain hearing.

Ninth (Glossopharyngeal) and Tenth (Pneumogastric) Cranial Nerves.—These are rarely involved, but if so, they are generally

affected together, ordinarily in fractured base of the skull or in wounds in the upper part of the neck. In operations for cervical adenitis, goiter, and other neck lesions they are also occasionally damaged (Fig. 500).

Symptoms.—The chief of these are anesthesia of the throat, palatal paralysis, disturbances of taste and salivary function, and irregularities of pulse and respiration.

There is no case on record of isolated injury to the ninth nerve alone (Starr).

Division of one pneumogastric may cause little or no permanent effects on the heart or respiration.

Treatment and Prognosis.—These are related to the associated injuries.

Eleventh Cranial Nerve (Spinal Accessory).—This has two nuclei, and the trunk formed by their union divides shortly after its exit from the skull into two branches, the external supplying the sternomastoid and trapezius; the other enters the trunk of the pneumogastric.

Causes.—Fractured base of the skull and intracranial injuries (rare); fracture-dislocation of the cervical spine; wounds of the neck; and sometimes shoulder injuries, like dislocation or fracture. Operations about the neck are also common sources of origin.

Symptoms.—If the lesion involves the nerve prior to the bifurcation, there will be paralysis of the sternomastoid and trapezius, and also signs related to the pneumogastric, such as laryngeal paralysis and anesthesia, palatal paralysis, and difficulty in swallowing, with alterations in pulse and respiration.

Most of the cases involve the external branch of the nerve, so that more or less paralysis of the sternomastoid and trapezius exists, the latter being usually less advanced than the former because partly innervated by the cervical nerves.

In a typical case the posture is quite characteristic, in that the head is held forward and tilted toward the involved side, the shoulder droops and shows atrophic flattening, and the scapula is drawn away and somewhat rotated; in addition, the arm cannot be elevated beyond a right angle and lifting power is much decreased.

Treatment.—The initiating and associated conditions are cared for first, and when possible suture is attempted. Later, massage and electricity are used, and finally resort may be had to nerve anastomosis when other means fail.

Prognosis.—Partial involvement is followed by recovery quite uniformly. Complete severance usually means permanent loss of

shoulder function to some degree, and operation offers the only prospect of recovery.

Twelfth Cranial Nerve (Hypoglossal).—This is rarely involved alone, and cut-throat and stab and bullet wounds are usually the extracranial traumatic factors. Occasionally it is involved during operations.

Symptoms.—Motor power is abolished on the side of the tongue corresponding to the lesion, and it thus deviates toward the paralyzed side and interferes with speaking and swallowing. Atrophy and furrows appear and the mouth becomes foul.

Treatment and Prognosis.—Suture is the only successful curative procedure; otherwise it is permanent.

Injury of the Brachial Plexus.—The whole plexus or of any of the nerves composing it may be involved, the lesions being similar to those found in any other isolated or group of nerves.

Causes.—Of these may be mentioned heavy blows; stab and bullet wounds; violent twisting motions of the head, neck, and shoulder; some severe fractures and dislocations of the spine, shoulder, or clavicle; cicatrices, as from deep wounds or burns; occupational, crutch, and other pressure sources, and stretching from forced posture, as during anesthesia, this last probably being the commonest cause.

Symptoms.—There are three general types:

(1) Total arm palsies.

(2) Upper arm palsies (Erb-Duchenne type).

(3) Lower arm palsies (Klumpke type).

In all of these the paralysis is the main feature, as the sensory changes do not correspond to the motor involvement because of the overlapping segmental cutaneous cord supply and nerve anastomoses resulting in the so-called "supplementary sensation."

The usual involvement is of the *upper arm type*, also called "Erb's palsy," and here there is paralysis of the deltoid, supra- and infraspinatus, teres minor, biceps, brachialis anticus, and supinator longus and brevis. This causes an adduction of the arm and inward rotation of the shoulder, and the forearm is pronated and extended at the elbow, so that the arm loses abduction and external rotatory power and the forearm cannot be flexed or supinated. Atrophy and electric changes also occur. In some forms of this type the deltoid, biceps, brachialis anticus, and supinator longus are alone affected.

All of these muscles may normally be made to contract by applying an electric current to "Erb's point," which is a spot 2 cm. in front of the sternomastoid and the same distance above the clavicle.

The *lower arm type* (Klumpke's palsy) affects the first anterior dorsal root through which pass the sympathetic fibers for the eye. Involvement of this sort causes paralysis of the small muscles of the hand with signs of involvement of the sympathetic, such as contracted pupil, narrowed palpebral fissure, sinking in of the eye, absent cilio-spinal reflex, and flattening of the face. This type is extremely rare by itself.

Prognosis.—If the lesion is due to contusion, stretching, or partial tearing, the outlook is good and perfect recovery is the rule. If avulsion has occurred, the condition is permanent until restoration is effected by suture or anastomosis. In severe cases recovery may take years before it is complete.

Treatment.—This depends upon the extent and site of the lesion, and usually little can be done at first except to care for the associated injury. Primary suture is indicated as promptly as the accompanying damage permits. If improvement occurs from the use of massage and electricity, no operation is indicated until these measures cease to be effective.

Operation designs to cleanly expose the divided nerve ends and bring about their junction by suture. Later, massage and electricity are used.

Circumflex Nerve.—This supplies the teres minor and deltoid; and in some shoulder injuries, notably dislocations and severe sprains or contusions, it may be injured. It is rarely hurt in gunshot or other penetrating wounds (Fig. 501).

Symptoms.—Early loss of the normal rotundity and consequent flattening of the region of the shoulder-cap due to deltoid atrophy is the chief sign. This muscle becomes soft and flabby and the arm cannot be elevated, and may become depressed enough to produce subglenoid dislocation. Sensory involvement is shown by a triangular area of anesthesia at the upper and outer part of the deltoid. The abolition of teres minor function is unimportant. Electric changes occur as in other neural injuries.

Prognosis.—It is important in dislocation and other injuries to determine whether the nerve was injured before or after treatment, and this is sometimes quite difficult in the presence of pain and swelling. In division or extensive damage to the nerve resumption of function is not likely to be complete, but in temporary or partial injury restoration will occur with appropriate treatment.

Treatment.—In the reduction of dislocations great care is needed so that the nerve will not be damaged by overstretching or actual laceration.

Early massage and the use of electricity and shoulder elevating gymnastics are the important and recognized measures. In complete laceration or serious damage (as indicated by electric tests) the propriety of operation for suture or anastomosis is to be considered.

Long or Posterior Thoracic Nerve.—This supplies the serratus magnus. It is rarely injured alone, but may be involved by contusions or wounds of the neck or shoulder, or forced muscular contractions.

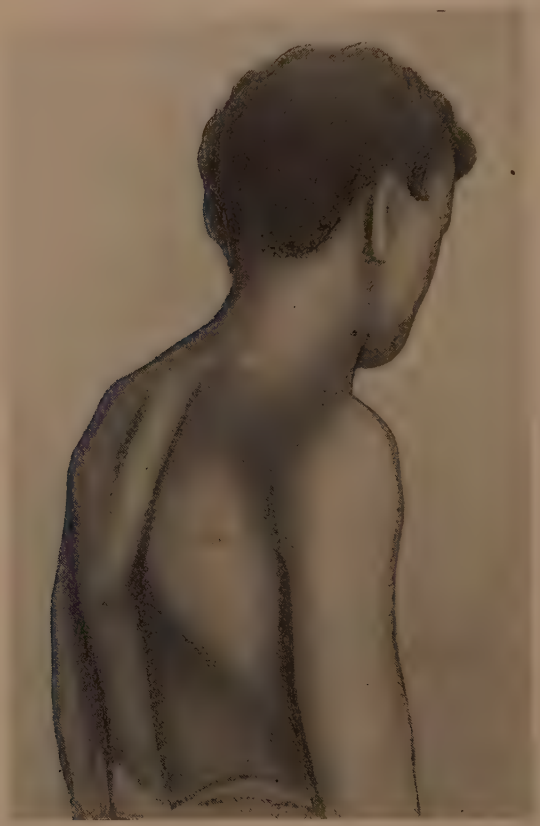


Fig. 501.—Deltoid atrophy following circumflex nerve injury.

Occasionally it is an occupational paralysis from carrying weights on the shoulder.

Symptoms.—The scapula becomes unduly prominent and assumes the so-called "winged" appearance, notably at the lower border. The inner border of this bone becomes more oblique from above down and in, and may be tilted upward. Elevation of the arm may be interfered with so that the patient learns to swing it before seeking to elevate it.

There is a good deal of pain about the neck and shoulder. Electric changes are present in marked cases.

Prognosis.—Slow recovery is the rule unless the nerve has been cut or seriously damaged, as by compression in a scar; in the event of the latter the outlook is bad.

Treatment.—This is the same as for circumflex involvement. A brace or strapping to bind down the scapula is of value also in some cases.

Suprascapular Nerve.—This is very rarely involved alone, and when it is, atrophy of the supraspinatus muscle occurs, causing depression of the fossa and some loss of outward rotation of the arm.

Prognosis and *treatment* are the same as for the preceding.

Musculospiral Nerve.—This supplies notably the triceps, brachialis anticus, the supinators and extensors, and, because of its long course, it is more often involved than any other nerve of the brachial plexus, and, indeed, is one of the most common of all nerve injuries.

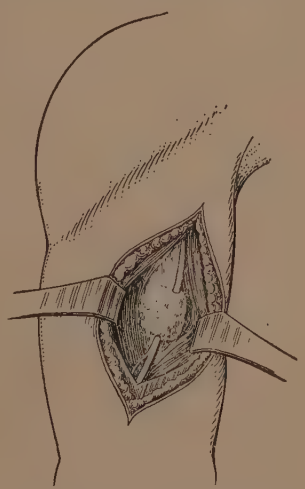


Fig. 502.—Musculospiral nerve included in the callus of a fractured humerus.

Causes.—Pressure, as from a crutch, bandage, or during anesthesia or sleep, is one of the commonest sources; "Sunday morning palsy" is the name given to that form occurring in a patient who falls asleep with the inner side of the arm hanging over a bench, chair, bed, or other continuing pressure source. Fracture of the clavicle is an occasional, and fracture of the arm (notably the middle third) a very common, source (Fig. 502). Contusions, wounds, and forcible muscle movements may also be factors. Shoulder dislocation is rather a rare source.

Symptoms.—These depend on the location of the lesion, the arm muscles escaping if the injury is below the axilla or upper arm, as there is a special branch of the nerve for the triceps. Upper involvement abolishes extension at the elbow, and lower involvement affects the supinators of the forearm and the extensors of the wrist and all the fingers.

The most familiar and typical symptom is "wrist-drop," so that the hand hangs limp and the patient cannot raise the wrist or *first* phalanges.

If, however, the hand is held, the *terminal* phalanges can be extended and the fingers separated. The thumb cannot be abducted or extended. The lost supinator action causes the hand to pronate when any wrist or finger flexion is attempted, and thus gripping or push and pull power and flexion of the forearm are lessened. This loss can best be ascertained by placing the inner side of the forearm on the table and asking the patient to raise the forearm against resistance. Sensory loss is manifested by numbness and tingling along the outer side of the forearm and the back and outer side of the arm (Fig. 503).

Atrophy appears in severe or long-standing cases and is proportionate to the extent of the damage, as also are the electric changes, but degenerative reaction may not appear even with rather pronounced lesions.

Prognosis.—Most cases get well, although it may take six months to attain full recovery.

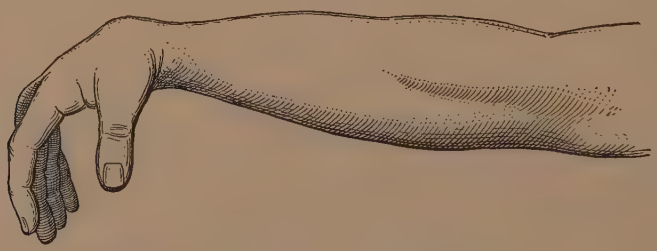


Fig. 503.—Wrist-drop in musculospiral paralysis.

Where the paralysis is secondary to the initial injury (as from treatment, scarring, or callus) operation may be required.

Wrist-drop from other causes (poisons and infections) must not be confounded.

Treatment.—This is the same as for any other type of neuritis. Where there is reason to suspect that the nerve has been caught or cut, operation is imperative.

Much success has been obtained by operation even after years of involvement, and the outlook is more favorable than with any other nerve of the extremities.

Median Nerve.—This supplies the pronators; the flexor carpi radialis; flexors of fingers; the thumb abductors, flexors and opposers; and the two outer lumbricales which flex the first phalanx.

Causes.—Ordinarily it is not involved alone except in wounds of the arm, forearm, and wrist; less often shoulder injuries are responsible. Tight bandaging or splintage is another source.

Symptoms.—Pronator loss causes some outward rotation and inability to place the forearm palm downward. Wrist and finger flexion is interfered with by damage to the involved flexors, although the action of the intact muscles supplied by the ulnar allows some flexion. The thumb has a tendency to adduct and stay in a position of extension and cannot be brought to the other finger-tips.

Sensory changes are limited to areas of varying anesthesia corresponding to the front and back of three and one-half outer fingers, as shown in Fig. 504. Pain in the hand occurs sometimes. Atrophy may show in the thenar muscles and trophic changes in the skin and

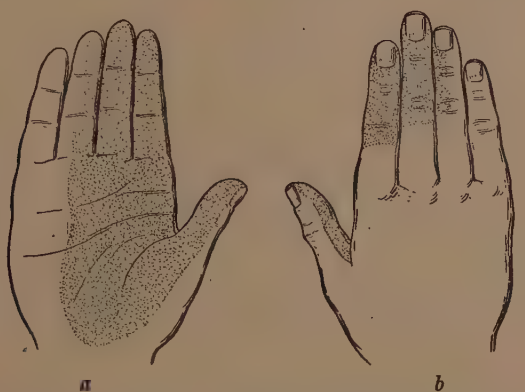


Fig. 504.—Median nerve paralysis: *a*, Sensory impairment, palmar aspect; *b*, sensory impairment, dorsal aspect.

nails may also appear. Electric changes are present as in other allied cases.

Prognosis and *treatment* are similar to that of other forms of traumatic neuritis.

Ulnar Nerve.—This supplies the flexor muscles not innervated by the median; that is, the flexor carpi ulnaris, the ulnar half of the profundus flexors, the little finger muscles, the interossei, the two inner lumbricales, and the thumb adductors.

Causes.—Next to the musculospiral the ulnar is involved oftener than any nerve of the upper extremity. Injuries about the inner margin of the arm, forearm, and elbow (where the nerve lies in a groove behind the internal condyle) are very likely to initiate trouble; hence in this location contusions, wounds, dislocations, fractures, pressure (occupational or otherwise), and bandages or apparatus are factors.

A considerable number of cases are due to actual severance (by metal or glass) of this and other parallel nerves in the vicinity of the

wrist, and in such cases muscles and their tendons are usually involved also.

Symptoms.—Flexor involvement means loss of power in bending the wrist and two inner fingers, and when completely paralyzed the little finger is immovable. Interossei invasion means loss of flexion of the first and loss of extension of the second and third phalanges, together with loss of adduction and abduction of the fingers and adduction of the thumb. These two foregoing conditions produce a characteristic contraction of the fingers known as the *main en griffe* of Duchenne, or claw-hand, which is gradual in onset and most affects the little and then the ring finger.

Atrophy of the hypothenar eminence appears and the interossei shrink so that the bones and tendons may show prominently.

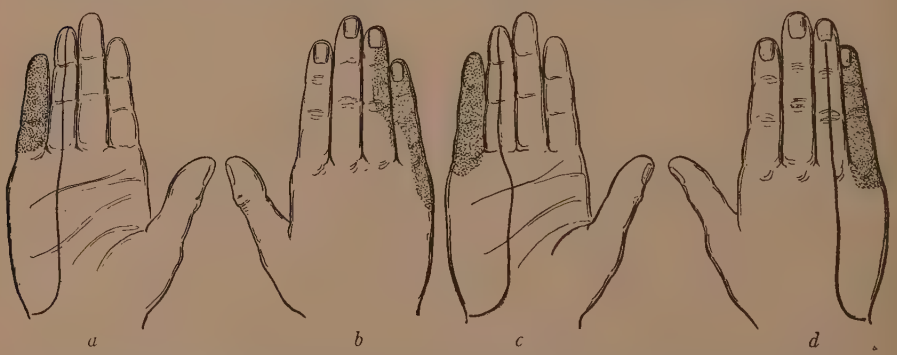


Fig. 505.—Ulnar nerve paralysis: *a*, *b*, Sensory impairment limited; *c*, *d*, sensory impairment diffused. The solid black line indicates the normal zone of distribution.

Sensory changes are indicated by numbness and tingling along the course of the nerve, and occasionally some pain is also present.

Anesthesia is limited to the zone shown in Fig. 505, and is generally well marked in the little finger, being most prominent when the nerve is inflamed.

Prognosis.—Most cases get well if the nerve is not caught or cut, the outlook being best gaged, here as elsewhere, by electric tests.

Treatment.—Primary suture is advisable when possible; otherwise the treatment is the same as in other types of neuritis. Operation is advisable in chronic cases and where laceration or compression exists.

Ulnar nerve dislocation is said to occur occasionally from injuries to the region of the internal condyle, a neuritis resulting. In a considerable number of persons the nerve normally does not lie in a groove, and in others it slips out of it on flexion of the elbow. In this class of individuals a more or less chronic neuritis often thus occurs.

Sciatic Nerve.—This, the largest nerve of the body, supplies with its branches all the muscles below the knee, but because of its protected position in the thigh it is rarely hurt (Fig. 506, *d*).

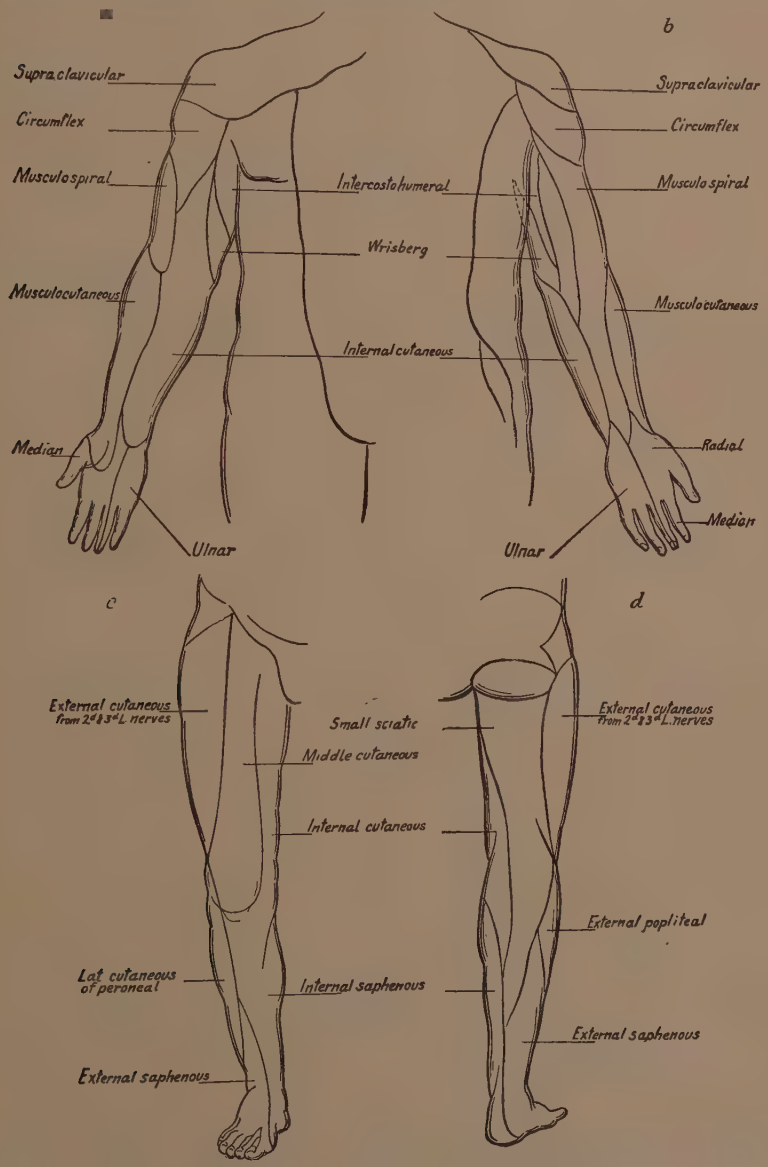


Fig. 506.—Sensory nerves of arm and leg: *a*, Arm, anterior; *b*, arm, posterior; *c*, leg, anterior; *d*, leg, posterior.

Causes.—Theoretically, injuries in the region of the hip and sacro-iliac joints should be causative, notably fracture and dislocation of the

femur; but, as a matter of fact, such is not the case, and Stimson is authority for the statement that cases are only recorded in association with hip dislocation or its reduction. Penetrating wounds are the commonest source of origin.

Symptoms.—In complete paralysis a peculiar gait occurs in which the hip is moved in a flail-like manner. Atrophy, loss of sensation, and electric changes promptly appear.

In *partial involvement* the manifestations usually appear below the knee and these will later be discussed.

Prognosis and *treatment* are similar to other forms of neuritis, and suture is the only efficient form of treatment in marked cases due to severance.

Sciatica is neuralgia of the sciatic nerve, and it is usually due to non-traumatic causes, of which may be mentioned rheumatism, gout, exposure to cold, diabetes, infections, alcoholism, postural or occupational pressure, pelvic, urinary, prostatic, or rectal disease, pregnancy, varicose veins, and various pressure sources.

Traumatic sciatica is usually a pressure neuritis.

Symptoms.—These depend upon the site, extent, and source of the ailment.

Mild cases manifest pain on pressure and tingling along the course of the nerve, with some disturbances of gait or muscle action.

Moderately developed cases are indicated by pain over the sacrum, buttock, and middle of the back of the thigh, and in severe cases the pain may extend over the entire nerve distribution. The pain is increased by pressure and motion, and the gait is so affected that flexion at the hip and knee is limited enough to produce a relatively characteristic walk so that there is a limping, stiff form of locomotion, the toe and leg being rotated and the weight thrown to the opposite side, and this posture is assumed even when standing. The patient is often able to sharply delimit the course of the pain along the route of the nerve, and this limitation is a differentiating factor in excluding rheumatism and other sources or allied trouble.

The pain is paroxysmal or dull and constant, and can be induced by movements that stretch the nerve, such as walking on stairs or bending the hip or knee.

Pressure tenderness can be elicited at "Valleix's tender spots," where the nerve is relatively palpable, namely, near (1) the posterior iliac spine; (2) the sciatic notch; (3) middle of thigh; (4) behind the knee; (5) below the head of the fibula; (6) behind the external malleolus; (7) on the sole (Fig. 507).

The pain is always deep seated and often increases at night; changes in temperature modify it and it is worse in damp weather. Attacks of pain may come on with lightning-like severity and be limited to the region of the knee, ankle, or sole. The patient adjusts the posture and gait so that pressure is removed, and thus the weight is placed on the opposite side and the knee and hip are supported in a bent position.

If a neuritis is present, the entire course of the nerve may be tender and thickened, and herpes may occur. Atrophy and loss of sensation may exist, notably at the outer margin of the limb.

Fig. 507.—Painful zones in sciatica.

Treatment.—The underlying cause must be relieved and suitable means taken to remove irritation. Anodynes and splintage and external applications are employed. Locally, ice and heat are used, and sprays of ethyl chlorid and the actual cautery are sometimes helpful. Injections of sterile water and various drugs are sometimes given directly into the nerve or its sheath, and forcible stretching is also of value, either by sharply bending the knee and hip or by operative exposure. Dietetic, hydropathic, and climatic treatment are valuable also.

Prognosis.—Traumatic cases offer a better prospect than those due to constitutional causes. The progress may be slow and recurrences are likely unless the initiating causes are kept under control.

External Popliteal or Peroneal Nerve.—The outer branch of the sciatic winds around beneath the head of the fibula and may become involved in fractures, dislocations, wounds, or pressure, this last quite commonly from the constriction of bandages, splints, and apparatus, notably plaster casts, during treatment of fractures. Other non-traumatic causes are plentiful. It is the homologue of the musculospiral of the upper extremity.

Symptoms.—This *peroneal palsy* induces paralysis of the tibialis anticus and the long peronei muscles and toe extensors, and hence adduction with falling of the foot and toes occurs, resulting in "drop foot" (Fig. 508). The gait is then quite characteristic and of the "steppage" type, the foot being raised high so that the toes will not

dangle. Contraction of the tendo achillis occurs in long-standing cases and atrophy and loss of sensation appear on the outer side of the leg and sole. Electric changes may also occur.

Prognosis and *treatment* are the same as in other forms of neuritis. Tenotomy of the tendo achillis and tendon transplantation may be needed in marked cases.

Internal Popliteal or Tibial Nerve.—Because of its deep position under the knee this other branch of the sciatic may be rarely involved by the same causative factors named for the peroneal nerve. In distribution it corresponds to the combined median and ulnar of the upper extremity.

Symptoms.—These follow from paralysis of the muscles of the calf and sole. The gait is much impeded and flexion of the ankle and toes is impaired and the patient cannot rise on the toes. The outer part of the foot and sole may be painful, numb, or anesthetic.

Prognosis and *treatment* are like the preceding.

Fig. 508.—"Drop foot" in peroneal paralysis.

Plantar Nerves.—These are branches of the posterior tibial, which latter is the continuation of the internal popliteal nerve below the knee. Isolated injury is rare except from long-continued sources of pressure, as from scars and callus. Tight shoes and prolonged standing are frequent factors.

The internal plantar nerve corresponds to the median distribution of the hand; the external plantar corresponds to the ulnar palmar distribution.

Morton's toe is a pressure neuritis of the second digital branch of the internal plantar nerve as it passes between the great and second metatarsal bones. It is frequently due to congenital misplacement of the nerve, and when acquired is often associated with enlargement of the head of the adjacent metatarsals. It is common in those who are required to stand or walk a long time, and hence policemen, letter carriers, and others similarly employed are liable to contract it. It may also affect other digital branches and is often associated with trouble in the arch of the foot.

Symptoms.—Pain of a steady or paroxysmal type, usually brought on by walking, occurs along the course of the nerve, and this may be very severe and associated with cramps in the muscles of the leg and foot. Walking may be painful or impossible. Snapping of the bones may also be present (Fig. 509).

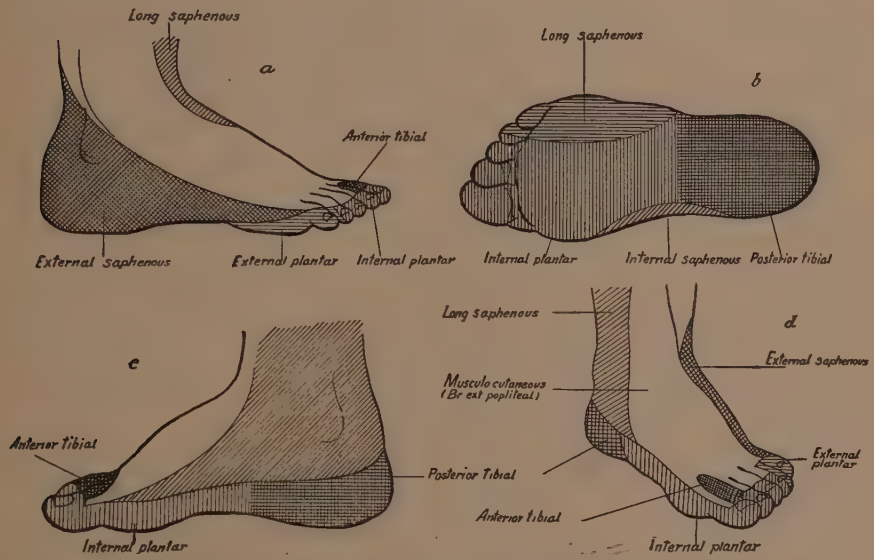


Fig. 509.—Superficial sensory nerve supply of foot: *a*, Anterolateral surface; *b*, plantar surface; *c*, posterolateral surface; *d*, anterior surface.

Prognosis and Treatment.—Proper shoes that support the arch, separate the bones, and do not constrict the ball of the foot usually suffice; otherwise resection of the nerve or the head of the metatarsal may be necessary. The latter is quite uniformly effective.

Injuries of the Blood-vessels

Injury of Arteries

Wounds and contusions may cause varying manifestations at the site of the trauma, but clinically all the pathologic conditions occurring in such vessels usually arise from internal causes dependent upon altered states of the circulating blood.

In this latter class fall the various inflammatory conditions, such as *arteritis*, *peri-arteritis*, *arteriosclerosis*, and the obstructive group, variously known as *obliterative endarteritis* or *thrombo-angiitis obliterans*. These arterial conditions are the result of *disease* and not of *injury*, and they are mentioned here because so often discovered in a

routine examination called forth by some accident. This is notably true of arteriosclerosis and the thrombotic types of circulatory lesions in which the condition has ordinarily existed for years and the symptoms perhaps have been ascribed to various other ailments.

Sometimes the occurrence of gangrene in an extremity at the site of a trivial injury is often difficult to explain until an examination discloses arteriosclerotic or obliterative arterial changes. The preliminary signs of these obstructive arterial changes in the lower extremities are often regarded as rheumatic or neuralgic, inasmuch as complaint is made of various pains in the legs associated with lameness or some spasm of the muscles and transient edema. Later, or in association with the foregoing, complaint may be made of various kinds of paresthesia, notably "pins and needles," and sensations referred to as the "feet and legs going to sleep," with more or less unsteadiness in walking. This group of symptoms was given the name of "intermittent claudication" by Charcot. This condition is not at all infrequent in early life, and for some unknown reason Russian Jews are especially subject to it; it occurs also among users of tobacco.

In passing, it is to be noted that locomotor ataxia and other luetic manifestations are to be differentiated, and cardionephrititis and diabetes are also to be excluded. The gangrene occurring from these sources may affect patches of the extremity, but it predilects the terminal phalanges, and is ordinarily of the *dry* or *senile type* and does not assume *moist* manifestations unless infection is present, or blebs have broken down.

Treatment.—This is usually wholly unavailing so far as surgical removal of the underlying cause is concerned. As a prophylactic such patients should be cautioned against self-treatment, for even so slight a condition as a "bark of the shin," that might pass unnoticed ordinarily, may be a very serious matter in the presence of obliterative changes. Inasmuch as the condition is progressive, the injury is usually but an incident in its development and cannot in any way be regarded as causative.

When *gangrene* does occur, the question as to the level of amputation may be quite difficult to decide. A test that has been recommended is to elevate the limb as high as possible and then apply a constriction at the groin to shut off the circulation until the limb is blanched. The tourniquet is then slowly released, and where the circulation is deficient from obliterative changes the tissues will regain their normal tone very slowly, if at all. In this manner the level to which the blood reaches is shown sufficiently well to determine as to

the probability of obtaining viable amputation flaps. If, when amputating, a main blood-vessel is found blocked by a clot, it is proper to remove it by passing a rubber catheter or other instrument into its lumen; this procedure is known as "arterial catheterization." Amputation flaps should be very loosely sutured, and if their vitality is subsequently impaired the surgeon should wait until a line of demarcation brings about spontaneous separation or accurately delimits the blood-supply. Of course, the presence of active infection may modify this course and demand immediate re-amputation at the requisite level.

Thrombosis and Embolism.—These never occur primarily as the outcome of an accident except where the vessels have been damaged either by direct violence or through septic infection.

Embolism of traumatic interest and importance is associated with fracture, and less rarely with infected wounds. Following fracture, especially of the long bones, fat embolism occurs occasionally during the progress toward repair; obviously it is more likely to appear in the first three weeks, during the period that osseous material is not abundant. Next in frequency are the cases occurring after healing is well enough advanced to dispense with the plaster cast or other fixed dressing; this is in the period from the fourth to the sixth week. Massage or active sudden usage of the broken limb may be provocative causes; but many embolic cases apparently have no external or obvious source of origin. Most of the cases I have seen have been in fractures of the shaft of the femur in men about fifty years of age.

Postoperative embolism is most likely to occur in operations requiring active interference with the blood-vessels, notably in septic conditions. Welch is the authority for the following list of arterial embolism as to frequency of location: pulmonary, renal, splenic, cerebral, iliac, and others of the lower extremity; retinal, superior mesenteric, inferior mesenteric, abdominal aorta, and coronary of the heart.

Symptoms.—Apparently there are severe, moderate, and mild cases in order of severity, and obviously the signs will depend somewhat upon the organ involved. It is to be remembered that *infection* is an essential prerequisite to embolism from wounds and that thrombosis may be a forerunner.

Pulmonary embolism in the severe form causes instant death from plugging of the pulmonary vessels.

The *moderate* and *mild* cases suddenly develop dyspnea, cyanosis, rapid pulse, an anxious appearance, and may go on to collapse. These signs disappear completely in a very short time, or they may be

followed by evidences of pulmonary infarction and thus resemble pneumonia.

Treatment.—This designs to relieve the respiration by oxygen inhalations; meanwhile the heart is stimulated by drugs like strychnin, whisky, or caffein.

Kidney embolism is hard to differentiate from nephritis, and the diagnosis is generally presumptive and the treatment is that of nephritis.

Cerebral embolism presents the signs of apoplexy and requires the same treatment.

ANEURYSMS

Generally speaking, any persisting sacculation, dilation, or widening of a blood-vessel can be called an aneurysm; but from a surgical standpoint the essentials are (1) that the sac must be directly continuous with the caliber of the artery; (2) that the blood-containing sac must be defined or encysted (Fig. 510).

There are two general classes:

(*a*) *True aneurysm*, or aneurysma verum, in which one or all of the arterial coats make up the sac.

(*b*) *False aneurysm*, or aneurysma spurum, in which extraneous material goes to form the sac, such as blood-clots or connective-tissue formation from them; these are always traumatic in origin.

The preceding are further subdivided by Thoma into five classes: (*a*) Congenital; (*b*) pathologic; (*c*) traumatic; (*d*) embolic; (*e*) cirsoid. The *congenital form* is exceedingly rare; the *pathologic form* is generally due to some septic particle setting up an endarteritis. *Embolic forms* occur in a cavity bathed in germs, as in a tubercular lung. *Cirsoid forms* are due to anastomoses between vessels. *Traumatic forms* fall into the class of false aneurysm and are relatively rare, and occur usually from direct injury to the vessel, as from wounds due to bullets, stabs, or other perforations. Some cases ascribed to indirect forms of violence, like muscular efforts or twists or blows, are more properly chargeable to other causes, as most of them give evidences of allied medical disorders, such as arteriosclerosis or syphilis. Occasionally fractures and dislocations initiate false aneurysms; and in some few instances efforts at reducing dislocations have been causative.

In some areas effused blood will form a sharply defined hematoma that may pulsate from the beating of an adjacent artery; such a condition is then known as a *pulsating hematoma*, but it is not to be regarded as aneurysmal because there is no definite sac in connection with the lumen of a vessel. This lesion most commonly occurs in the region of

the femoral, popliteal, and facial arteries. Efforts at producing traumatic aneurysm in lower animals are said to fail unless there has been previously some diseased or damaged state of the vessel wall (Keen's *Surgery*).

Arteriovenous Aneurysms.—In these there is a communication between an artery and a vein so that they join directly (*aneurysmal varix*) or through the intervention of a sac (*varicose aneurysm*).

Causes.—Injury is the commonest source, and bullet and stab wounds provide the majority of cases. The weapons of modern warfare are especially prone to cause this sort of injury now that the lancet of venesection is no longer used. Venkerquam states that the essentials for this form of aneurysm are "a small orifice of entrance and exit of the bullet; a narrow but long curved channel usually crossing the vessel in an oblique direction; a small perforation in the artery followed by rapid closure of the wound and primary union of the bullet track."

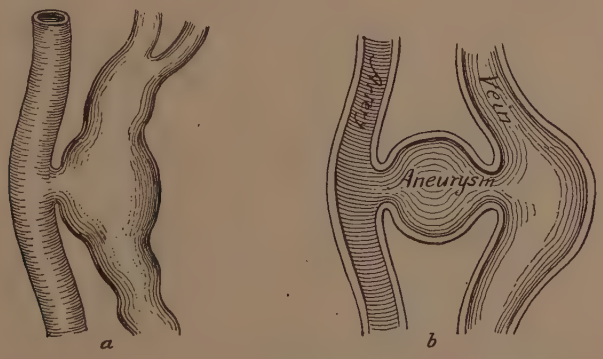


Fig. 510.—Forms of aneurysm: *a*, Aneurysmal varix; *b*, arteriovenous aneurysm.

Varicose aneurysm is the commonest form, and it occurs ordinarily in regions where the artery and vein are somewhat separated.

Symptoms.—In *ordinary aneurysm* an expansile, more or less ovoid, pulsating tumor is felt and usually seen; the adjacent veins may be somewhat turgid; the overlying skin is movable and the veins are often dilated enough to give it a "marbling" appearance. Pressure may vary the size of the tumor, and if so, it quickly regains its former size on release therefrom; this is a pathognomonic sign. Posture may change the character of the palpatory signs, and the pulse on the affected is smaller than on the opposite side. A bruit is heard with each pulsation and this may be transmitted slightly; it is altered by pressure on or above the tumor. The patient may complain of pain, pulsation, or various symptoms indicative of altered blood supply or neural pressure.

Diagnosis is rendered easier because of the existing wound. A pulsating swelling is noted as one of the initial signs, and this may appear coincidently with the injury or within a few days or weeks thereafter. There are a few rare and not well-authenticated cases in which several months are said to have elapsed before the tumor appeared. This original swelling may continue to increase in size or may remain stationary. There may be visible enlargement of the tributary veins in some superficial locations, and ecchymoses may also appear. In accessible locations the *pathognomonic thrill* is palpable and of a purring character, very striking, and unusual when obtainable. The *bruit* is also typical and is likened to the buzz of machinery, the droning of bees, the whirr of a bird in sudden flight, or the humming of a top. The *thrill* and *bruit* in conjunction are sufficient for a diagnosis. There may be associated signs of circulatory embarrassment, as in other aneurysms, especially if a limb is involved. The patient may also complain of the "roaring" or "buzzing" sounds if the tumor is in the neck or head.

Recently, at the Surgical Section of the Academy of Medicine, I presented a case of arteriovenous aneurysm of the facial vessels due to a .32 caliber bullet entering at the angle of the lower jaw, penetrating and furrowing the cheek, and making exit in the middle line of the upper lip. There was not much bleeding, but a large hematoma appeared on the cheek and the ecchymosis extended to the neck. On the third day pulsation over the swelling made me suspicious of an arteriovenous aneurysm, but the bruit was not very apparent, and I then regarded the condition as a pulsating hematoma. Next day the bruit appeared in characteristic fashion, and in ten days only an almond-sized pulsating lump remained and over it the typical sound was apparent. The patient referred to "a swishing sound as if a hive of bees buzzed in my ear," but otherwise he had no subjective symptoms. Pressure over the facial artery as it crossed the ramus of the jaw stopped the thrill and the bruit, and caused the hard lump to disappear. Operation after two months demonstrated no definite sac, and the artery and vein were ligated at the proximal and distal ends, resulting in cure.

Treatment.—Operation offers the best chance in the traumatic forms, and this may be performed by any of the accepted methods.

In ordinary aneurysm the suture and reconstruction or obliteration of the sac (Matas' operation) is a method of choice.

Arteriovenous forms are not operatively treated unless definite indications exist, and it is best to wait several months when possible, as some cases spontaneously disappear unaided; in others, firm proxi-

mal pressure appears to cause subsidence (Vanzetti's method). If symptoms demand and the case is suitable, intrasaccular suture or obliteration may be effective. In others, proximal and distal ligation with exsection of the sac may be needed. In main vessels (like those of upper arm and thigh) anastomosis or transplantation methods may be necessary.

Injury of Veins

These vessels are subject to the same sort of injuries as arteries, but because of structural differences they respond somewhat differently under similar circumstances. The total capacity of the venous system is stated to be seven times that of the arterial, and for that reason the entire blood of the body may be found in the veins after death (Stimson).

The *valves* in veins constitute their chief peculiarity, and these are of greatest importance in lesions of the lower limbs, and play a major part in various other conditions. These bicuspid valves open toward the heart and are placed at regular intervals, and are capable of supporting the intervening column of blood.

Wounds involving the lumen of veins produce hemorrhage that is differentiated from arterial bleeding, in that it is more oozing and darker in character and "wells" rather than "spurts" out.

Phlebitis.—This means an inflammation of the walls of a vein, and the process may begin in the lining coat or extend to the latter from a periphlebitic origin.

Causes.—Damage to the endothelial coat is the essential feature, and this almost without exception is due to infection of some sort. Clogging of the vein to some extent is inevitable, and hence the ensuing *thrombosis* is of the *thrombophlebitis* type. Various diseases, like typhoid, pneumonia, grip, gout, rheumatism, and the exanthemata, are frequent sources of origin.

The *surgical* causes are the outgrowth of contamination of the venous stream from some pus focus, the staphylococci and streptococci being the most common offenders. Examples are found in sinus and venous involvement in middle-ear disease and the portal phlebitis following abdominal operations (notably appendicitis). Pus-containing wounds or ulcers are another source, and by metastasis the original focus may infect a far distant site because infected emboli are carried in the venous channel. In this manner an infection on the foot may be responsible for a similar outbreak on the face; or the reverse. The common postoperative venous inflammation, *phlegmasia alba dolens*, ordinarily occurs in the left leg because of the anatomic differences of

the iliac vessels on that side of the body; this condition, however, most commonly manifests itself as a postpuerperal incident and is a typical thrombophlebitis.

Phlebitis from injury proceeds invariably from a pus focus due to the existence of an initial wound in the skin or mucous membrane, and the condition is generally of the *septic* or *pyogenic* variety.

Symptoms.—Following a wound there may be some local evidences of infection (redness, swelling, discharge, heat, and pain), and gradually or suddenly these signs appear along the track of the vein and constitutional disturbance becomes prominent, with adenitis, fever, chills, prostration, sweats, and other evidences of pyogenic infection. Other less severe cases may manifest only pain and cord-like or general swelling, with tenderness along the palpable veins. If a limb is involved, it will be hot, red, swollen, and tender. Areas of abscess formation will show by local spots of softening, and when these spontaneously rupture or are incised, the contained pus is thick and brownish and often odorous. In some cases a series of abscesses form along the vein like beads on a string. In severe cases metastases may occur in the liver, lungs, kidneys, or elsewhere.

Treatment.—Attention to aseptic and antiseptic details in wounds is a valuable preventive.

The two cardinal therapeutic elements are to provide by elevation (1) rest and (2) diminished venous pressure. If a limb is involved, the use of some lotion (like lead and opium) or ointment (like ichthyol) may prove agreeable, a bulky dressing being provided in addition. The part is then elevated and supported in a comfortable position. No active interference should be attempted until pain and swelling are much abated, and then *very gentle* massage in an upward direction can be given at a distance from the infected zone, and at the same time the adjacent joints may be gently moved. Ordinarily such manipulation cannot be safely given for several weeks. If *abscess* occurs, incision and drainage is indicated.

Septic thrombophlebitis, if accessible, is occasionally successfully attacked by ligation, or by ligation and incision of the involved venous segment.

In all cases general treatment is exceedingly important and the patient needs active systemic support, proper diet, and stimulants. Out-of-door treatment is exceedingly valuable and most patients will profit if kept there day and night, suitably protected. Various silver salts externally and intravenously have been recommended, but I have never known them to cure. Vaccine treatment is more promising and

I have seen beneficial results from its use, especially in the septic types. Autogenous vaccines appear to act best; but the polyvalent stock vaccines are often equally active.

Varicose Veins.—This condition means permanent enlargement or dilatation of the venous channels due to changes in the coats of the vessel.

The lesion is most typically seen in the lower extremity, especially the thigh, leg, and scrotum, notably on the left side. The lowermost part of the body is most affected because of gravity, weakness or absence of the valves, pressure from the intra-abdominal contents, the contraction of the muscles of the calves, and the lack of support for the internal saphenous and other superficial veins. Some cases are congenital and in others there appears to be a familial relationship. According to Da Costa, 20 per cent. of adults have varicose veins in some part of the body, and 80 per cent. of cases begin before the twenty-fifth year.

The subject is discussed because it plays such an important part in accidents and not because it is primarily traumatic in origin.

Causes.—Aside from the foregoing mechanical or anatomic considerations there are certain other factors:

Age.—Two-thirds of the cases occur before the fortieth year.

Sex.—Men are more affected than women, pregnant women excepted. Garters cause some cases.

Occupation.—Standing, walking, or straining are often provocative, and for these reasons waiters, clerks, laborers, postmen, policemen, and others similarly employed are often affected.

Pregnancy and *tumors* are important causative elements.

Diseases, like constipation, liver, kidney, and intestinal troubles, that interfere with portal circulation are often causative; arteriosclerosis is a potent cause, and a similar change in the veins (phlebosclerosis) may be equally responsible.

A single or isolated *injury*, like a contusion, wrench, sprain, or wound, is never causative unless some phlebitis has been set up resulting in venous stasis, thrombosis, or consequent dilatation. Obviously such a sequence would not at first affect more than a single venous channel and those closely tributary to it.

Long-standing cases are associated with lesions in the adjacent vascular and neural vessels so that arteriosclerosis and changes in the nerves and their sheaths occur (interstitial or perineural fibrosis). The skin often becomes leathery, shrunken, and adherent, so that lymphatic circulation is interfered with and edema appears (elephantiasis

phlebectatica). Eczema is common. These changes may also affect the bones and lead to osteoporosis.

The essential pathologic change in the vein occurs in the media and the phlebosclerosis lengthens and hardens the vessel, and in this and other respects arteriosclerosis is paralleled.

Hemorrhoids, varicoceles, and enlarged veins of the lower extremities are the commonest varieties.

Symptoms.—These may be limited to the presence of a more or less tortuous vein that becomes more prominent when the part is placed in a dependent position or when the return circulation is impeded. The accompanying veins or those tributary to the main trunk may also share in the enlargement. If the process is extensive or if it has lasted a long time, edematous and nutritional signs appear, notably in the lower extremity. Here there may then exist considerable swelling, so that at night or after standing a ridge may appear at the shoe top; in some cases the swelling may be great enough to require special foot-gear or bandages, or even interfere with walking. Eczematous areas may form, with or without a break in the skin, and the integument may become leather-like in color and texture. A brownish-black or blue mottling may also appear, and a yellowish or copperish pigmentation sometimes occurs. *Pain* is a frequent accompaniment, and this may be diffuse or limited to the course of the main vein or involve an adjacent nerve trunk or its filaments. *Neuralgia* of main nerves is not uncommon, and in the lower limb the sciatic nerve is often involved from edema or actual varices of peri- or intraneural origin. Sensations of weight and various paresthesiæ are sometimes complained of, so that the patient says the "leg goes to sleep," or has "pins and needles in it," or it becomes unduly cold or warm. *Rupture* of a dilated vein with varying degrees of hemorrhage may occur spontaneously or follow slight injury; this is especially common when the veins are beaded, knobbed, or knotted, notably in those near the shin. Subcutaneous rupture may cause considerable ecchymosis or hematoma formation, and when the leakage is in the deeper muscles, notably in the calf, sharp, severe, disabling pain may occur. These are the so-called "coup de fouet" or "whip-lash" cases that so closely resemble the tearing of muscle-fibers or tendons, notably injury of the plantaris.

Varicose ulcers are exceedingly common and may follow minor bruises or abrasions, especially when the latter are infected by improper treatment. They are commonest along the shin where the blood-supply at best is limited.

Periostitis and *osteitis* may coexist from an original injury or develop secondarily from local infection.

Leg ulcers (*ulcer cruris*) may occur from so slight a cause as scratching, or a pimple, and nearly all of them due to skin breakage follow superficial wounds, such as a "bark of the shin." The vast majority have been self-treated for a variable time, and when they come to the surgeon are usually much infected. Eczematous areas are often the starting-point, and nearly all of them show a surrounding area of intertrigo from exuding pus. In old cases there is often an area of dry, scaly, cracked, pigmented skin in proximity. In the alcoholic, rheumatic, gouty, arteriosclerotic, tubercular, and syphilitic the manifestations are usually greater and the course more protracted. Many are in areas previously ulcerous, eczematous, or otherwise devitalized. These cases form a very large percentage of dispensary patients and are commonest in persons over forty-five, especially women. Ancient cases may be quite extensive, with calloused insensitive margins and considerable edema that may amount almost to *elephantiasis*. *Lymphangitis* and *cellulitis* are occasional accompaniments.

Diagnosis of long-standing valvular venous insufficiency is made by the *Trendelenburg test*, as follows: The patient lies down and the leg is raised high until all the veins empty or collapse. A finger is then pressed over the saphenous opening and kept there while the patient stands up. Then the finger is removed, and if the main vein fills from *above downward*, the valves are incompetent, as normally the vein should fill from *below upward*.

Efforts at straining or coughing or a tapping on the upper part of a dilated vein will often cause a palpable wave of fluctuation when the valves are incompetent.

Treatment.—Those predisposed should be encourgaged to seek occupations that minimize standing, walking, or muscular efforts. At every opportunity the leg should be elevated, and at night much good will follow raising the foot of the bed or mattress. Proper footwear and hose supporters should be provided. Habits and diseases should be suitably treated. Some form of elastic stocking will be helpful, but these are expensive and soon stretch and become odorous from use and perspiration. I find linen mesh bandages a valuable substitute; these are cheap, washable, durable, and elastic enough to accommodate the daily changes in the circumference of a limb. They need not be worn at night. Any support of this sort should be applied from the ankle to the knee, and above the latter also if occasion demands.

Hemorrhage responds to pressure ordinarily, and care is needed to guard against infection.

Ulcers.—(See pages 41–46.)

Operation is indicated when there is no visceral basis for the varicosities and in that class of patient where phlebosclerosis is not too far advanced. There are numerous types of operations, but that of multiple linear incisions and exsection of the intervening segments meets the average indications. Encircling operations (Schede's and others) are less advisable because of the occasional occurrence of gangrene following the scar contractures.

Injuries of the Lymph-vessels

The main surgical interest of these lesions arises in connection with wound infection leading to lymphangitis and lymphadenitis.

Thoracic duct injury is so uniformly a part of fatal accidents, like throat-cuts or bullet wounds, that recognition of it in life is rare. It is occasionally injured in operations about the neck, and may then become immediately manifest by the appearance of the characteristic milky chyle, or this substance may later exude through an external sinus or collect in the thoracic or abdominal cavity, producing chylothorax and chylous ascites respectively.

Rapid emaciation, great thirst, difficult respiration, and exhaustion promptly appear, and within a few weeks death is certain in the presence of a marked lymphorrhea.

If the injury can be recognized early enough, the duct can be implanted into the internal jugular vein; failing this, it may be tied, feebly trusting to collateral circulation.

Contusions over lymph regions may very rarely produce a *subcutaneous lymphorrhagia* resembling hematoma, except that the fluid is proved by aspiration to be yellowish and non-coagulable. Pressure ordinarily causes their disappearance, other interference being rarely needed and rather dangerous.

Lymphangitis and Lymphadenitis.—Inflammation of the lymph-vessels and of their tributary glands is very common, the infection being commonly of the streptococcic variety introduced through some break in the skin, although the organisms may rarely gain access through the undamaged surface. It more commonly follows small and rather deep penetrations than large open or gaping wounds. Trivial and perhaps temporarily forgotten wounds on the hands and feet furnish the largest number of cases.

When the smaller network of lymph-vessels is involved, it is known as *reticular lymphangitis;* and when it affects the larger collecting vessels it is called *tubular lymphangitis*, although both forms may be combined.

Symptoms.—The cardinal signs of inflammation are promptly present, and with the reticular form, redness, pain, heat, and swelling may be circumscribed and resemble a dermatitis or erysipelas; or in the tubular form, red, diffused, palpable, tender streaks lead from the wound focus parallel to the course of the veins and end in swollen tender glands (lymphadenitis), and abscesses may here subsequently appear. These two forms often coexist, and as the bacteria enter the lymph-vessels septic thrombi may form, and soon adjacent and often distant tissues become infected by metastases.

If the condition remains localized, constitutional signs are lacking; but if the infection is severe or generalized, the classic signs of sepsis appear, namely, irregular temperature, elevated pulse, chills, sweats, and prostration. Extreme forms may eventuate in delirium, followed by coma and death.

When the deeper lymphatics are alone invaded, pain, tenderness, and fever may be the only signs until surface brawniness and rigidity indicate the probable beginning of an abscess.

The swollen glands are likely to remain hard and tender for some time after the subsidence of acute symptoms.

If the original wound is still open, a purulent or foul sanious discharge may or may not be present; but with a free vent the occurrence of lymph infection is less likely. Occasionally lymphadenitis may go on to abscess formation at a considerable period after the primary source of infection has healed; this is, of course, more likely in constitutional (tubercular, specific, chancroidal cases) than in traumatic types of infection.

Treatment.—Immediate sterilization of all wounds is the main prophylactic factor. Early cases are treated by rest, elevation, and wet dressings of equal parts of cold water and alcohol, iodin water (1 dram to pint), boric acid, or aluminum acetate. The wound is given a free vent. Circumscribed or brawny areas not responding to this treatment are incised, and abscesses are thus treated as early as recognizable. Beyond this, the management is that of septic infection in general. Swollen glands may persist a long time after active symptoms subside; they require no attention ordinarily.

Prognosis.—Most cases get well; deep infections and those of streptococcic variety are more dangerous and may lead to metastases unless early brought under control.

See also Infections of the Hand, pp. 62–85.

CHAPTER XVI

BURNS; HEAT STROKE; FROST-BITES

Burns

These may be caused by heat applied by liquids, solids, flames, and various forms of radiant heat.

Of the common sources of origin may be mentioned boiling liquid solutions causing *scalds*, as from water, oil, steam, or tar. Hot metals and combustible materials provide another large group, and chemical and electric contact furnish examples less numerous. Hot-water bag burns also occasionally occur.

Practically speaking, they should all be regarded and treated as infected wounds due to heat.

Varieties.—Commonly, three grades or degrees are described, but most cases present some of the signs of all types.

First degree burns produce only superficial involvement, characterized by reddening or actual inflammation of the outside layers of the skin or exposed surface, but there are no blebs and scarring does not occur. This is also known as the stage of *hyperemia*.

Second degree burns produce skin inflammation and blebs or vesicles because of deeper involvement. Scarring does not usually occur, but pigmentation is likely to follow. This is also known as the stage of *vesication*.

Third degree burns produce actual destruction of the skin layers and may even penetrate to the parts beneath, with escharotic or charring manifestations. Scarring always results. This is also known as the stage of *escharation*.

A *fourth* form, showing extensive manifestations of the preceding, is sometimes described.

Symptoms.—These depend upon the degree and source of the burn, and to some extent upon the age and physique of the patient.

Systemic or *general* signs are those of *shock*, and evidences of this promptly appear in burns of all degrees if much of the body surface is involved. It has been stated that burns involving more than one-third the surface area of the body are likely to be fatal; and in children the susceptibility to fatal shock is three times greater than in adults.[1]

[1] Weidenfeld, quoted by Lieber, *Beitr. z. Klin. Chir.*, lxxxi, November, 1912.

There are numerous exceptions, however, to this, and burns of the head and upper extremity are capable of inducing marked shock often when relatively small areas are involved. The onset of shock is prompt and often leads to delirium and coma.

Fever and *pulse rise* is quite common (after shock subsidence) and is independent of any infection in the first few days at least.

Vomiting and *diarrhea* sometimes occur; blood may appear in the excreta, and gastroduodenitis or actual signs of duodenal ulcer develop quite often. This last is now supposed to be due to adrenal involvement. I recall one case of this sort in which a man inhaled hot vapor in a superheated steam room of a Turkish bath, and, becoming unconscious, fell against a hot iron radiator, receiving very severe burns of his back, extremities, and other parts of his body. He had bloody vomitus and stools at the end of the first week, together with much epigastric pain, localized tenderness, and rigidity. He subsequently recovered despite the added complication of nephritis.

Nephritis may be occasioned, and albumin, and hyalin, granular, and blood casts may be found as part of an exudative nephritis. Hematuria occasionally occurs and the urine is usually scanty and high colored.

These various foregoing manifestations of severer burns are the expression of a toxemia of unknown type, but which apparently has hemolytic properties. It has been shown that the urine and serum of such a patient are poisonous and capable of inducing in another similar symptoms when injected. Death as a direct result of shock or toxemia almost always occurs within six days, but in children a fatal ending may not eventuate until the twelfth or fifteenth day (Lieber).

Of all burns, my experience is that shock and complications are greatest in those due to boiling liquids and inflammable materials (clothing, bedding, and household goods); electric burns produce the least systemic manifestations and the minimum of pain.

Burns of mucous membranes from inhaling steam or flame are likely to be serious, if not fatal.

External or *local* signs depend on the degree of the burn, and the location and source of it.

First degree forms cause stinging or burning pain, redness of the skin, and perhaps some swelling and local heat. Desquamation may follow. Sun burns are of this type. Shock may be a factor only if the bodily extent of the burn is extensive.

Second degree forms are exaggerations of the preceding plus blebs, vesicles, or blisters. These occur at once if the burn is localized and the

temperature of the source is high, otherwise they may not appear for several hours. In size they are variable, and those that do not spontaneously rupture soon contain pus. If punctured (designedly or otherwise) the parts under them will be red, angry and painful, and exude more or less serum. Unless aseptically punctured, pus quite regularly appears, crusts form, and a more or less eczematous condition arises. When healing occurs, the part remains dark for a variable time, but eventually this pigmentation usually blanches into the normal skin color. Shock to some degree generally appears.

Third degree forms cause actual destructive changes in the deep layers of the skin and often in the parts beneath. They ordinarily occur from prolonged contact with materials of very high temperature, as from molten or other metals. The resulting burn may produce actual charring, so that the part may be quite black; or the eschar produced may be gray, yellow, or more or less mottled, and dry or moist. The superficial appearance may not at first denote the true depth of the process and this may remain a matter of surmise until sloughing appears. Infection quite regularly occurs and the process then becomes one not unlike ulceration.

Shock is a regular accompaniment, and other systemic evidences of toxemia may become apparent by symptoms referable to the gastro-intestinal and urinary systems as already indicated.

Treatment.—Shock and the other complications are treated as if they had arisen from any other source. It may be stated, however, that the continuous hot immersion bath is an excellent adjunct, as this combats the general and local signs in one medium and is especially indicated when large surfaces of the body have been burned.

Practically speaking, burns are infected wounds and they should be treated as such.

First degree forms need only a moist cold dressing of salt solution, boric acid, or other mild lotion. After the surface has been swabbed with one-half strength iodin, a 10 per cent. solution of alcohol in ice-water is very agreeable. Later, sterile olive oil or some mild ointment will do much to prevent the tight or puckered feeling over the area about to "peel off."

Second degree forms should have the bleb punctured aseptically at the junction between the sound and unsound skin, the part having been first painted with one-half strength tincture of iodin ($3\frac{1}{2}$ per cent.). A moist dressing of sterile saline or boric solution may then be applied and every effort made to prevent pus formation. If it does occur, the secretion is washed off and then a pink solution of permanganate of

potash or iodin solution (1 dram to 1 pint of water) may be used as a wet dressing on gauze. Later, and when granulations begin, a *sterile* mild ointment or oil may be used, and balsam of Peru added to this will effectively aid in healing. Scarlet red ointment is excellent also at this stage, 1 dram being used to an ounce of sterile olive oil. The use of carron oil is to be condemned unless it has been previously sterilized, as the average combination is often stale and anything but aseptic. Picric acid in 2 per cent. strength has many advocates; personally I do not use it.

The posture of the patient is very important and the parts must be suitably guarded and kept apart to prevent contraction by scar formation.

The open-air treatment is ideal in a great many of these cases, and my practice is to make a wire or wooden cage to encircle the part and over this spread one layer of gauze to keep off dust while the patient is exposed to the direct sunlight or open air for increasingly long periods daily. Usually this part of the treatment begins on the second or third day. If crusts or sloughs form, they are to be cautiously removed and not roughly pulled away, as thus they may lead to ulcerations of a deeper type. When the patient is not exposed to the air, the burned part may be covered by some sterile oily dressing so that it may readily be removed for the ensuing air exposé. When the surface is pus free, red, and granulating, healing may be hastened by autogenous skin-grafting if the area is large. Personally, I have not had occasion to use grafting in several years since using open-air and sunlight treatment. Scarlet red ointment is extremely efficient at this stage. Thiersch grafts are the best, although flaps or pedicles may act as well. Amniotic and egg membrane have also been used with some degree of success. On old leg ulcers I have successfully used the fresh sac removed at herniotomy.

Third degree forms are treated as in the preceding, every effort being made to cause early separation of the sloughs. It is unwise, however, to dislodge eschars by force, as much bleeding and reinfection is thus occasioned.

Antiseptics of the mercurial and carbolic type are dangerous because of the possibility of absorption, and thus the less dangerous antiseptics, like permanganate and iodin, are preferable. Skin-grafting is very frequently required.

Scarring and *contractures* are quite likely to lead to deformities about large joints, the neck or fingers, and, in general, where there is much need of mobility. The preventive treatment is here most

important, and splints and posture must be as much a part of the procedure as careful dressings. In burns about the neck the head must be so tilted that the chin will not be drawn toward the chest. If the axillary region is involved the patient must be trained to keep the arms higher than the shoulders; likewise burns about the elbow, hands, knee, and foot must be treated with the idea that if contractures occur the stiffening of the joint will be at such an angle that the maximum and not the minimum of joint function may persist. The daily use of passive motion, followed by active motion, will do as much to limit joint stiffness in burns as it does in fractures and infections. If necessary, various plastic operations may be performed to restore contour or function.

Many of the scars remain for a time sensitive to pressure and weather changes, and they readily crack and may even ulcerate; eventually, however, these difficulties disappear.

Gastro-intestinal complications are best treated by careful dieting and the use of such drugs as bismuth, salol, and others of that class.

Urinary complications require the free use of water; urotropin, salol, and benzoate of soda may also be indicated. The presence of albumin is often an incident and does not necessarily indicate gross or lasting kidney damage even if associated with blood and various kinds of casts. These manifestations quite regularly disappear just as they do in any other toxemia.

Heat Stroke; Insolation; Thermic Fever

Two forms are described: (1) *Heat exhaustion;* (2) *sunstroke.*

Each of these is predisposed to by any set of causes tending to diminish bodily resistance, and of these may be mentioned fatigue, poor food, improper hygienic surroundings, and the excessive use of alcohol, notably beer and whisky. Actual exposure to the sun or hot weather may be the direct cause, but high temperature under any method of contact is equally causative. In our climate the majority of cases occur after a series of hot days, the seizures appearing while the patient is in the open. Another group is represented by stokers, firemen, and others who work in places of high temperature and are "overcome by the heat."

(1) **Heat exhaustion** may occur in or out of doors, and the onset is usually gradual, with a feeling of great exhaustion, headache, and dizziness, soon followed by nausea or vomiting that may lead to actual collapse. The patient looks flushed or pale, the skin is generally hot and dry, but may be bathed in cold sweat. The pulse is rapid and feeble

and the respirations shallow. Temperature is rarely over 103° F. and ranges from this to subnormal. The unconsciousness of the collapse is not profound, and the pupils if dilated will respond and the patient can be aroused.

(2) **Sunstroke** usually comes on suddenly and the patient is found unconscious and in collapse; less often the symptoms of the foregoing may first appear. Typical and well-marked cases manifest general or local convulsions of a tonic or clonic type. Such a patient has usually a flushed or hot skin, with a rapid and bounding pulse and stertorous respiration; later the cardiac and respiratory signs are those of collapse. The temperature is over 103° F. and may be so high in fatal cases that the average thermometer will not register it. Incontinence of bladder and rectum is common. Delirium frequently occurs if the temperature remains persistently elevated.

Treatment.—The indications are to (1) reduce temperature, (2) combat collapse, and (3) prevent complications.

(1) *Temperature* is best controlled by ice-water sponging, spraying, or baths. The usual procedure is to employ cold externally until the temperature shows a steady but not too sudden decrease, repeating the sponging, spraying, or bath if a sudden rise appears. Cold cloths or ice-bags are kept on the head after the patient is put to bed. A very sudden drop of temperature is a bad omen.

(2) *Collapse* is treated by hypodermics of whisky, strychnin, digitalis, caffein, or remedies of that type. If there has been much loss of bodily fluids and the pulse does not gain in *volume* by these means, repeated rectal use of a pint of salt solution and 4 ounces of whisky may prove effective.

(3) *Complications* like delirium tremens, pneumonia, anuria, intestinal hemorrhages, and continued vomiting demand appropriate treatment; but all of these are to be disregarded until the originating condition is relieved and the remaining temperature is definitely known to arise from a complication and not from the initiating or relapsing heat stroke.

Many of these patients remain for a long time intolerant to high temperature, and some of them have more or less well-marked evidences of peripheral neuritis, tachycardia, and impaired respiration. Subjective symptoms like dizziness, headache, various pains in the head and body, and special sense defects also may persist for a time.

Prognosis depends upon the individual, the extent and duration of symptoms, and the opportunities for prompt and adequate treatment. Alcoholics constitute the largest proportion of patients and in them the

mortality is highest. Patients surviving forty-eight hours usually get well, but those who have more than two relapses usually die. Persistent convulsions and delirium are bad features.

Frost-bites; Congelations

These may be due to sudden or prolonged exposure to cold and are usually best shown in involvement of the toes, fingers, nose, and ears.

Varieties.—Three grades or degrees are described, as in burns.

First degree frost-bites produce redness and more or less superficial inflammation of the skin. If this is repeated or continuous the affected part may swell, become livid, and less often desquamate or ulcerate, meanwhile being itchy or irritating, especially on changes of temperature; this condition is known as *chilblain* or *pernio*.

Second degree frost-bites result in the formation of blebs or blisters, and when these heal under a crust no scar usually remains.

Third degree frost-bites produce more or less deep ulceration and actual destruction of tissue, and in advanced cases gangrene occurs with detachment of the involved part.

By many this last manifestation is known as a fourth degree frost-bite.

Treatment.—*First degree* forms require restoration of circulation by friction and cold applications, such as rubbing the blanched finger, nose, or ear with snow or ice until the normal color returns, and meanwhile the progress from a cold to a warm temperature must be gradual.

Chilblains should be protected by adequate clothing. Locally the use of iodin, lotions like lead and opium, and various ointments will be of value.

Second degree forms are treated as in the foregoing, and later blisters are opened aseptically and dressed by some mild antiseptic.

Third degree forms are regarded as infected ulcers and treated accordingly. If gangrene is present, the line of demarcation should be awaited if possible, and in the interval the damaged part is kept *dry* and elevated, as these measures tend to prevent moist gangrene and the spread of the process.

In case of *general freezing* the patient is to be gradually "thawed out" by being placed in a cold bath in an unheated room, friction being applied by cold towels. After several hours the bath is to be gradually raised to the average room temperature (about 70° F.) and then the patient can be put to bed and further treated as required.

CHAPTER XVII

INJURIES DUE TO ELECTRICITY; TO COMPRESSED AIR OR CAISSON DISEASE; INJURY FROM ILLUMINATING GAS

Injuries Due to Electricity

Accidents from this source are relatively common owing to the wide-spread industrial use of electricity, particularly as a source of light and power.

What follows is very largely taken from the author's article of similar title read in March, 1909, before the Surgical Section of the New York Academy of Medicine, and subsequently published in the *Journal of the American Medical Association*, April 2, 1910, vol. liv, pp. 1127–1132.

Authoritative information as to the physical effects of electricity is very scanty,[1] especially in American literature, but in Germany (notably through the investigation of Jellinek[2]) and in France and Great Britain there has been much preliminary experimentation and subsequent case reporting by physicians; but in this country investigation has been limited almost solely to electric engineers, and case reports have been few in number.

For an intelligent understanding of the subject it is necessary to know some of the usual *technical terms*, and they can be stated thus:

The *volt* is the unit of pressure. The *ampere* is the unit of strength. The *ohm* is the unit of resistance. The *coulomb* is the unit of quantity.

But for all practical medical purposes it is enough to remember that the *volt* is the unit to express pressure, intensity, or electromotive force; and that the *ampere* denotes strength or rate of current flow. The volt is the impelling force which moves the electricity through any conductor. The *ohm* is the unit of resistance and expresses that quality of the conductor which resists the passage of electricity through it.

Electricity flowing through any conductor is impelled by the voltage applied to the circuit and is opposed by the resistance of the circuit. In direct current circuits, and in alternating current cir-

[1] In addition to the subsequent numbered references the following may be consulted: F. Batelli, *Rev. méd. de la Suisse romande*, 1902; M. A. Cleaves, *Ref. Handbook Med. Sc.*, iii, 742; Crile and Macleod, *Amer. Jour. of Med. Sci.*, 1905, p. 417; R. H. Cunningham, *New York Med. Jour.*, Oct. 21–28, 1899; H. L. Jones, *British Med. Jour.*, 1895, i, 468; J. H. Lloyd, *Med. News*, Nov. 24, 1894; Mills and Weisenburg, *University of Pennsylvania Med. Bull.*, March and April, 1903; E. A. Spitzka, *New York Med. Record*, January 4, 1902; *Proc. Amer. Phil. Soc.*, 1908, *Jour, Med. Soc.*, New Jersey, 1909.

[2] S. Jellinek, numerous articles in German medical journals.

cuits when the current and electromotive force are "in phase," the rate of current flow is directly proportional to the voltage and inversely proportional to the resistance. This rate is measured in amperes, and its numerical value is found by dividing the volts by the ohms (I=E/R; "Ohm's law").

Ordinary conductors carry currents of three varieties: Direct (or continuous), alternating, and interrupted.

The contact may be of four kinds, viz., *positive*, where the body is firmly and constantly pressed against the conductor; *partial*, where the contact is slight and steady; *brushing*, where the contact is slight and for a short interval, and *arcing*, where the current reaches the body via a vapor through which the current passes. The *intensity* may be (1) *low* (100 to 300 volts); (2) *medium* (400 to 600 volts); *high* (1000 volts and over); this classification being that adopted by Prevost and Batelli, of Geneva, as the outcome of many experiments.

The *duration of contact* may be (1) *short*, from one to five seconds; (2) *medium*, from five to eight seconds; and (3) *long*, from eight seconds upward.

Mode of receipt is generally by charged (1) wires or rails; (2) metal apparatus or tools; (3) flashes or arcs which are productive of burns only.

The average electric pressure in electric lighting is from 100 to 225 volts (direct or alternating), usually about 110 volts; in overhead and underground trolley systems, from 500 to 650 volts (direct); suburban lighting circuits, 1000 to 6600 volts (alternating with transformers to reduce the pressure for use); series arc lighting circuits, 2000 to 6000 (direct or alternating); in overhead, long-haul railway systems, as in the N. Y., N. H. & H. R. R., 11,000 volts (alternating), or, as in the C. M. & St. P. R. R., 3000 volts (direct). In third rail systems, like the New York Subway, the voltage is about 650 (direct). The highest voltage transmitted by wire in this country is that generated by the Pacific Light and Power Co., 150,000 volts. Another system transmits 120,000 volts between Cleveland and Nashville. The Toronto Power Co. transmits 85,000 volts from Niagara, and a Connecticut company uses 120,000.

A voltage of from 200 to 500 is usually not dangerous, but the alternating current is considered to be more dangerous than the direct, although Jellinek[1] believes the reverse. In the electrocution of criminals from 1300 to 2000 volts are used, the average being 1800 of the alternating type, the amperage being 7 to 9.

[1] *Archiv. Roentgen Ray*, January, 1913.

The **physical effects** are mainly determined by the following:

1. Amount and duration of current.
2. Site, type, and area of contact.
3. The individual.

1. *Amount and duration of current* is the main essential, and the greater the degree and the longer the duration, the greater the effect. High voltage, long duration, and positive contact generally predicates coma, severe systemic shock, burns, and oftentimes death. Medium intensity, with medium duration and partial contact, generally means burns of the second or lesser degree, less profound coma and shock with more or less paresthesia, especially numbness and tingling. Low intensity, with short duration and brushing contact generally means burns of the first degree or none, slight, if any, coma, and moderate paresthesia, mainly of the tingling type. Low intensity, with brief duration and partial contact, generally means absence of burns or systemic symptoms, paresthesia of the formication type being generally alone complained of.

Amperage is so variable that it has not been mentioned because of its uncertainty, but the higher it is, the greater the effect in general: $\frac{1}{10}$ ampere is generally regarded as safe; over 1 ampere is usually fatal, assuming that the other factors are proportionate.

2. *Site, type*, and *area of contact* is less important, pursuant to the physical law that electricity takes the shortest route between two electrodes, and this has led to investigation to determine the resistance of various bodily elements to the transmission of electric energy. This pathway of the current is along the route of least resistance, and Jellinek states that one path is through, and the other over, the surface of the body. It has been found that the tissues transmit proportionate to the amount of their fluid constituents; the more saline this is, the better the conductivity. Blood is the best conductor, mainly because of the saline serum. Muscle comes next, nerve tissue follows, and bone is a poor conductor. Similarly, experiments have shown that the bodily tissues exert varying resistance to the passage of electricity, as denoted by the unit of resistance, the ohm. The average human resistance is 1000 ohms. Dry skin is very resistant, and one observer (Jolly) says that this is 150 times greater than that of the underlying tissues. Jellinek states that the average resistance of the integument varies between 30,000 and 100,000 ohms, and may reach 1,000,000 ohms for calloused hands. A dry, hard, thick skin offers more resistance than one that is moist, soft, or thin; an acid or alkaline perspiration reduces the resistance, while an oily skin raises the resisting power.

If a strong alkali be applied to the skin so that the oily secretions are removed, the resistance is much lowered, so that the subject experiencing little effect from 100 volts might be disturbed by 10 volts. Larrat[1] says that if muscle is given a standard resistance of 1, then nerve and cartilage can be denoted by 2.5; bone as 15 to 20; and the skin and epidermis as between 100 and 500. Electric energy meets greater resistance passing transversely to the axis of a tissue than when transmitted longitudinally, this being 6 : 1 in muscle, 3 : 1 in nerve-fibers. Turner's experiments indicate that transmission from hand to hand meets with a resistance of 1375 ohms; through one hand, 900 ohms; from cheek to cheek, 600 ohms; from one supramalleolar region to another, 700 ohms; and through the calf of leg, 350 ohms. Nerves and blood-vessels are the vulnerable points.

As compared with any metal, the body is a poor conductor, it being calculated that muscle is 115,000,000 times a poorer conductor than copper. It has also been estimated that 1 inch of the sciatic nerve has eight times the resistance of the Atlantic cable.[2]

The greater the area of contact, the greater the effect, especially if the current traverses vital parts, notably if the heart is in circuit.

3. The *individual* variation means the personal equation, and it is strikingly similar to that of drug idiosyncrasy, notably as to sex, age, physique, occupation, and temperament. Males are less affected than females; the aged offer less resistance than the young on account of the constituents of the blood-vessels; those of rugged and muscular physique have a greater conductivity than those of the opposite type; the phlegmatic are subjectively less prone than the neurotic; those accustomed to electric energy are often less influenced than the novice. Illness, sleep, and alcoholism render persons less sensitive.[3]

Variations as to time of day, type of clothing, amount of food in the stomach, and general well being all seem to exert some influence; but the given effect cannot always be determined by these factors, and I have known electric workers to have practically no effects from contact under circumstances that left no doubt as to high voltage traversing the system. If the person is prepared for or expects the shock the effect is better borne.

Physical Effects.—In a general way these are three in number:

1. Deaths.
2. Burns.
3. Nervous symptoms.

[1] Electrothérapie, quoted by Dawson Turner, *Manual of Practical Medical Electricity*, p. 188.

[2] Beard and Rockwell, p. 168.

[3] F. B. Aspinwall, *Lancet*, 1902, p. 660.

Death from electricity is usually sudden, and is best represented by the execution of criminals, lightning stroke, and unexpected contact with highly charged materials, the body completing and short-circuiting two conductors. Under such circumstances there may or may not be decided external evidence of what has occurred, any such taking the form of burns of varying degree, areas of lividity or ecchymosis, or simple crimsoning to mark the place of entrance or exit of the current. It is, however, very unusual for a lethal dose of electricity to fail to leave some visible evidence at the points of contact. Postmortem, such cases are surprisingly free from gross microscopic changes, and the most careful search of all the tissues has as yet failed to give any adequately uniform cause of death. The findings in general are not unlike those following drowning or suffocation. The body of Czolgos, assassin of President McKinley, was subjected to the most minute scrutiny, especially by Spitzka's examination of the brain and cord, but nothing more than the customary fluidity and venous stasis of the blood with flaccidity of the heart muscle was found. In a still more recent autopsy of an electrocuted murderer the same negative findings were recorded. Still later, Spitzka and Radasch[1] report finding in the brain of five electrocuted criminals peculiar circular areas ranging in diameter from 25 to 300 mm. The authors believe these to indicate the electrolyptic action of the current liberating gas bubbles. Observers appear to have two main theories to account for death under such circumstances: one being that the heart muscle is paralyzed by a tetanic spasm analogous to that observable in skeletal muscle under high voltage; and the other theory, that there is a definite cellular destruction, especially of the vital centers. In connection with this last, it has occurred to me that the disintegration that seemingly takes place may generate toxic materials, thus adding a chemical to a mechanical irritation that almost immediately kills. Death from low tension current is by heart fibrillation; heart and respiration alike fail from lethal medium tensions; and respiratory failure is the cause of death in high tension accidents.[2]

Burns by electricity differ from those due to extremes of temperature only in origin, and they may be of the usual first, second, and third degrees. An electric burn is an index of resistance of the tissue affected, and always indicates that the full strength of current has not been received. The character of the burn is sometimes determined by

[1] *Amer. Med. Jour. Sci.*, Sept., 1912.

[2] L. Minot, Des accidents causés par l'emploi industriel de l'électricité, etc., Paris, 1908, p. 21, quoting Prévost and Batelli.

the type of metal acting as a conductor, and burns by arcs and flashes from copper conductors sometimes produce less severe burns than those emanating from iron or steel. By contrast with burns due to flame, or contact with steam, hot solids or liquids, deep electric burns are apparently less painful, produce less systemic shock, and heal more quickly. This was vividly impressed on me in a recent Harlem Hospital service, where in adjacent beds lay patients who sustained irregularly distributed burns of all degrees in an incendiary fire, and also those who had received "third rail" burns; the former had more systemic symptoms, the burns were more intractable to treatment, and the complaints of pain were greater than in the latter class of cases. This is probably due to the fact that electric destruction of tissue is sudden and absolute, as if done by electric cautery. The contrast is even greater by comparison with burns from hot liquids, such as boiling water, oil, or tar, and this irrespective of the surface areas involved. The resultant scarring and contraction appear about equal, even though electric burns are often more diffusely distributed over widely separated areas than burns of other kinds. Many electric burns are characterized by the lack of suppuration and the smoothness of the resulting scar. If the clothing is ignited, there is added the element of heat burns to those which may be the direct result of electric contact. Sometimes metallic particles are deposited on the skin (as if electroplated), causing a brownish, dry, stiff, painless burn that leads in a few days to a flaky peeling of the skin.

Burns resulting from partial or arcing contact often heal slowly and show a tendency to slough or to become gangrenous, especially if the trophic supply is involved. Cases of this type sometimes give external signs disproportionate to the underlying damage, and the severer symptoms may be a few days in appearing, and then show as isolated or confluent areas of a more or less gangrenous type. From the time of receipt of burns of this kind to the outbreak of severer manifestations the interval period is always filled by symptoms indicative of more or less deep-seated damage, in addition to the superficial evidences.

I have had many opportunities to examine cases of electric injuries, and one of the worst of these was the following:

CASE 1.—*History.*—S., a laborer, was working in a manhole repairing the "channel rail" of one of the surface roads, the current of 550 volts being turned on. In some manner he fell against this charged rail so that his back contacted at about the lower scapular level, his feet being grounded on concrete. He remained in that position several minutes and when released was found to have a third degree burn that practically eschared his back

from midscapular to the lower lumbar region, and it is said that the burn reached far enough to expose the underlying viscera. He suffered profoundly from shock and was unconscious, and his recovery was protracted. Even at this date (six years later) there is an unhealed area about 3 by 4 inches in the central portion of the scar, but all except this space cicatrized without skin-grafting in a remarkable way considering the original extent and severity of the wound.

Subsequent History.—Some years later he was seen and exhibited by me, and at that time he had a butterfly-shaped scar 13½ by 11 inches in the involved area, in the lower portion of which was a supposed lumbar hernia. The scar had contracted enough at first to almost draw the wings of his scapulæ together and spinal flexion was impossible; but by continued self-bending and manipulation of his back he so far recovered as to be able to

Fig. 511.—Third degree electric burn extending from midscapular to lower lumbar region.

resume manual labor. Later he was operated on by me and the supposed lumbar hernia proved to be retracted bundles of muscle-fiber. The above-mentioned unhealed areas were covered by autogenous Thiersch grafts, but healing was not yet complete in January, 1910. He at no time developed a traumatic neurosis (Fig. 511).

Case 2.—*History.*—Another severe case was that of D. H., aged twenty-three, iron-worker, born in Finland. He was working on an iron trestle repairing overhead wires of a suburban electric and steam railroad, and, while assuming an upright position, his left occipital and clavicular regions contacted with a wire bearing 11,000 volts, and he became temporarily unconscious. Through the courtesy of Dr. F. B. Littlewood he was seen with this physician ten days later at the New Rochelle Hospital, and at that time he was able to be out of bed for a portion of each day.

Examination.—He then presented numerous sloughing and granulating burns of the left upper extremity and chest, and an extensive third degree burn of the left occiput

and of the soles of the feet. He had little if any systemic shock or sepsis. There was no nervous involvement organically or functionally. Mentally he was as apt as could be expected, considering the fact that about one-sixth of his body was more or less badly burned.

The duration of contact in this case could not be ascertained, but it must have been short and imperfect, as it is to be noted that the contact was on the head and the left upper extremity, and that he was grounded by his feet standing on a metal support so that the main part of his body was temporarily a part of the circuit. He wore no hat, and his shoulders were bared except for a thin shirt, and he had no tools in his hands. Theoretically this man should have been unable to withstand electric shock of that volume, but the burns evidenced the fact that only a portion of the voltage was received. I am told by Dr. Littlewood that he made an excellent recovery, and that his progress and subsequent symptoms were those typical of severe burns.

CASE 3.—*History.*—I am also indebted to Dr. Littlewood for notes of the case of J. M., who was working on the same railroad and who came in contact with a transformer so that his left shoulder apparently received 11,000 volts.

Examination.—He immediately became unconscious, and when seen at the New Rochelle Hospital by Dr. Littlewood had severe burns of the entire left half of the body, and the sole of each foot showed two large blebs about the circumference of a dollar. His temperature ranged from 98° to 99.°4 F., pulse 99 to 120, respirations 20 to 40. The next night he began to vomit, and developed an uncontrollable singultus. The vomitus became biliary, and assumed the type seen in gastroduodenitis following severe burns of this or other origin.

He died early on the fourth day apparently from systemic shock. In this case the manner and duration of contact was problematic, but it is stated that the contact was for an appreciable time and that he was probably grounded on metal judging from the blebs of the feet. It is to be noted that the respiratory rhythm was more disturbed than that of the heart, and that his temperature was at no time more than one-half degree below normal. Death in this instance was probably due to respiratory failure accompanied by paralysis of the diaphragm. No autopsy was permitted. The cause of the gastroduodenal symptoms in any class of severe burns has never been satisfactorily explained, and it is generally a bad feature.

Nervous Symptoms.—In the absence of direct destructive or inflammatory damage to nerve-fiber and the subsequent development of a more or less localized neuritis, the nervous effects are almost invariably those of the hysteroneurasthenic type, it being rare in my experience to find either neurosis separately as a consequence of electric or any other form of trauma. I have never known an organic disease of the central nervous system to develp from the passage of electricity through the body, nor does the available literature narrate more than one instance of this nature. If a direct injury has been done to nerve-fiber the symptoms will be those corresponding to the distribution of the affected nerves, and hence no description is needed.

Where direct injury to nerve tissue is absent or minor in extent, the subsequent development of neurasthenic and hysteric symptoms is generally psychic in origin or dependent on auto- or heterosuggestion, and the signs then presented are usually disproportionate to the

actual physical damage sustained. Such cases rarely present objective evidences of electric contact and occur usually in those predisposed because of a neurotic or actually hysteric temperament. The flash, spark, or arc from charged metallic contacted points occasionally induces this set of nervous symptoms, either with or without bodily contact. Cases of this and allied sorts are often designated by the term "electric shock," and less frequently as "electric neurosis"; but the symptoms do not differ in any essential respect from the ordinary shock or neurosis attributed to any other trauma.

Examination of such a patient develops a wealth of subjective symptoms and a poverty of objective symptoms, and the average case will correspond to the following:

CASE 4.—*History.*—Mrs. F. was alighting, during a rain, from a suburban electric car operated by the overhead trolley system. While she had one foot on the car platform and the other on the metal step, her hand being on the dash-handle, she claims to have received a "shock," the force of which threw her face downward to the ground. She was stunned but not unconscious, did not vomit, and when assisted to the adjacent sidewalk was able to discuss the occurrence with some show of agitation and not a little anger. She walked unaided to her home nearby and saw her doctor some few hours later. He gave her lotions for the bruises of the knee, elbow, and hands. There were no burns or obvious electric effects, but she did complain of tingling and needle sensations in the hand that touched the dash-handle and in the foot that contacted with the metal step.

When I saw her some fourteen days after the accident she was abed, somewhat pallid, and had a characteristically tense and drawn expression, and was markedly irritable in manner and speech, all of the foregoing being said to be foreign to her normal state. There was an abvious rapid tremor of the closed eyelids, about the angles of the mouth, and of the outstretched fingers and protruded tongue. External evidences of injury were lacking aside from a fading area of bluish discoloration over a palm-sized area just above the right knee, probably from her fall. No evidences of electric contact, or of so-called "electric shock," were present. No paralyses and no areas of diminished sensation; conjunctival and pharyngeal reflexes absent; marked dermographia; knee-jerks lively, all others normal. Romberg sign marked; no Babinski or allied manifestations. Gait was normal and pulse rapid. There were areas of shifting tenderness along the spine, these being very inconstant and readily brought out by suggestion. Two spots were found in the upper dorsal region consistently tender, but she leaned back in a chair on these same areas and made no complaint. There was no contraction of visual fields and no color distortion.

Here is a typical case of the milder form of recoverable hysteroneurasthenia, and she had many symptoms that might as well be stigmatic as symptomatic. She recovered perfectly in a short time.

Contrasted with the former mixed type of functional nervous disturbance, the following case of almost typical hysteric motor paralysis with milder neurasthenic symptoms is narrated:

CASE 5.—*History.*—G., an electrician, was admitted to the Harlem Hospital with a history of having been injured two weeks previously in an out-of-town power-house, the patient stating that while holding a dead wire in his left hand, some one turned on the

current of 110 volts and his hands and fingers were burned; immediately fingers of the left hand contracted; it felt as if an electric current passed through him every time his fingers were touched; he claims to have lost all sensation over entire left upper extremity; and says that he cannot move his fingers; he has had other electric burns, but was never affected in this manner before; the current entered the palm of the left hand, but the place of exit is unknown.

On examination the left hand presented the pseudo-Dupuytren's contraction appearance indicated in Fig. 512, palmar flexion at the metacarpophalangeal joints of the inner four fingers being marked, that of the ring and little finger being most prominent. There was no apparent atrophy, nor was there any burn or other sign of trauma. He would not permit the slightest manipulation of the extremity except when his attention was diverted, and then the fingers could be partly extended. He claimed loss of thermal and tactile sensation over variable areas from the elbow down; but these shifted, especially on suggestion, and followed indefinite nerve distribution. Active motion of the wrist was limited; that of the elbow and shoulder normal. He would not permit passive motion, nor would he consent to electric tests. The examination as to his general state showed him to be in excellent condition except that he was of neurotic type and presented many hysteric stigmata and neurasthenic manifestations.

During the fortnight intervening between the accident and his entry to the hospital he was under the care of a physician, who had given him some internal medication with local application of iodin, and who is said to have made a diagnosis of "paralysis from electric shock." At no time were splints or retentive forms of apparatus employed. He would not consent to the proposed anesthetization, nor would he allow a dorsal splint to be applied, and accordingly he was dismissed from the hospital with a diagnosis of "hysterical paralysis of hand." There was unquestionably an element of voluntary exaggeration in this instance as so often happens in that class of case in which litigation is pending. When seen a month later he had regained function enough to do his usual work but still had many subjective complaints.

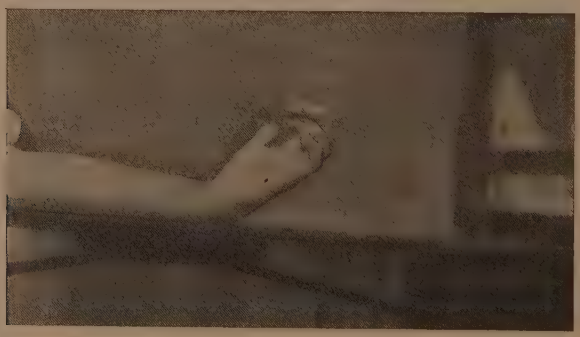


Fig. 512.—Pseudo-Dupuytren's contraction as the result of electric burn, showing marked palmar flexion at the metacarpophalangeal joints of the inner four fingers.

Occasionally there are cases recorded in which blindness and deafness and other special sense defects have been attributed to electric contact or flashes, but all instances of this sort are of the hysteric variety, and fall into the class of so-called "fright neuroses." An example of this sort came to my notice recently in which "blindness" was said to have been induced in a susceptible woman by the flash

and spark display when an overhead trolley wire was struck by a metal beam. She was seated in her room some 200 feet away from the scene of this brilliant display of light and sparks, but within sight and sound of the occurrence, and she claimed that she experienced the sensation of a ball of fire dancing before her eyes, and she immediately became sightless. Examination showed no organic defect of vision; the case was one of hysteric amaurosis induced by fright in a susceptible person. Vision returned within a short time.

Other Effects.—Crile[1] says that high-tension currents produce no chemical change of importance in the various tissues and organs aside from the burning at the place of contact, and that the blood is unaltered, To prove this, a current of 2300 volts (alternating) was passed through the head of an animal, and during the ensuing month of observation there was no discoverable loss of function. The same observer also says that when atropin is administered before the current is applied the inhibitory effect is almost wholly obviated, except when the current passes through the heart muscle, and then death ensues.

Treatment presents no special problems, inasmuch as it is for the relief of shock, burns, or neuroses. In cases of profound injury, and even where death has apparently occurred, prolonged artificial respiration should be maintained, as in drowning cases, with compression of the chest wall in the precordial region; even digital compression of the heart itself has been proposed, but never successfully practised. The pulmotor and lungmotor have proved of value, but until they can be operated artificial respiration must be diligently given. Crile recommends rhythmic pressure over the heart area, the tongue being drawn out, as he says that this combines circulatory and respiratory artificial stimulation.

With the foregoing manual methods the use of various stimulants of the atropin, strychnin, and adrenalin sort is also advisable.

Burns are treated after the manner indicated for other burns (see p. 618), and it has been observed that the so-called open method of treatment is especially efficacious in this type of burn. Exsection of the involved area and subsequent suture is also advised for some third degree forms; I have never found this necessary.

Neuroses are best treated by isolation, plus the mental and therapeutic means named in discussing neurasthenia and hysteria (see p. 670).

Prognosis depends on the extent of the initial inhibition symptoms;

[1] G. W. Crile, article on Surgical Physiology, *Keen's Surg.*, i, 79 *et seq.*; Crile and Dolley, *Jour. Exper. Med.*, 1906, viii.

in patients that survive forty-eight hours the prognosis is that of the absorption of septic and toxic products from the burned areas, with the development of cardiac, respiratory, or kidney complications, and with, occasionally, the presence of fatal gastro-intestinal disturbances.

The ultimate scarring and contraction from the burns require no comment. Neuroses do not ordinarily develop until after the patient has recovered from the main objective symptoms, and these nervous manifestations then frequently stand in relationship to a pending claim, and recovery does not usually ensue until adjustment is effected.

Conclusions.—It can be stated that there is no special form of physical effect inherent to electricity, inasmuch as every symptom can be paralleled by other forms of trauma. Likewise there is nothing pathognomonic in electric shock, and the symptoms of it are those common to other forms of systemic shock, with or without burns or neuroses. The duration of symptoms is no more prolonged after electric than other forms of trauma; nor does there appear to be any sound basis for the claim that one electric shock renders the patient more prone to similar experiences, but, on the contrary, an acquired immunity seems to be created by repeated applications. Electricity is well understood scientifically and is governed by well-known physical laws, and there is no good reason for the view often expressed that its effects on the human economy are unusual or peculiar.

Injuries Due to Compressed Air; Caisson Disease

This is an incident of occupation and occurs among those who work under forced atmospheric pressure in the construction of tunnels, bridges, subways, foundations, or other subsurface work carried on in compressed air locks, chambers, or caissons.

The normal atmospheric pressure is 15 pounds to the square inch, and workers in compressed air are subjected to an average pressure ordinarily between 30 and 40 pounds.

Hill states[1] that he and his assistants have been subjected to six and seven atmospheres of pressure without suffering harm or discomfort. In subaqueous construction, for every 5 feet below the surface of the water, about 2 pounds additional pressure is needed. Thus, at a depth of 37½ feet beneath the surface, 15 additional pounds pressure would be required, and this is technically known as "two atmospheres." Pressure less than this usually causes no symptoms, and some work is carried on with a pressure as high as 55 pounds.[2]

[1] *Brit. Med. Jour.*, February, 1912.

[2] The author quotes freely from the articles of L. E. Hill, H. H. Pelton, and L. M. Ryan.

Physiologically, the condition is supposed to be due to the liberation of the dissolved nitrogen gas from the blood into the tissues (Hill), the air having been absorbed under pressure by the blood with coincident increase of blood-pressure. For this reason, if the worker is gradually subjected to the forced pressure there are ordinarily no serious symptoms; the same freedom follows if the pressure is gradually reduced before the workman returns to the surface level.

The majority of cases occur from too rapid *decompression* when the worker is suddenly forced to accommodate himself to a change from about 35 pounds to the normal 15 pounds. An acute dilatation of the blood-vessels is said to occur under such conditions and the tissues of the brain and spinal cord are most readily affected, leading to evidences of pressure, edema, or hemorrhage.

Causes.—As indicated, the essential element is *too rapid variation of pressure*, and this ordinarily occurs during the passage from the lock to the surface. The Latin races are said to be more prone than others and the novice is more susceptible than the experienced "sand hog." Cardiac, arterial, pulmonary, nephritic, and alcoholic subjects are bad risks, and those under twenty or over forty-five years also do not act well.

Symptoms.—The *onset* is generally immediately after or during release from pressure; in some cases there may be a delay of a few hours, but very rarely is there a lapse of more than six hours. The later the onset, the milder the symptoms.

There are two main types, the *spinal* and the *cerebral*, and the manifestations vary accordingly.

Spinal Type.—This is the commonest and comprises approximately 90 per cent. of all cases, varying grades of severity existing.

Neuritis Grades.—Here the main symptom is pain in the limbs, usually in the calf or arm muscles; these may be cramp-like or shooting in character and occasionally may involve the muscles of the chest, abdomen, and back. Ordinarily these signs are constant, but may intermit or become paroxysmal; they are commonly known as *the bends*.

A respiratory form, with more or less dyspnea, cough, and sense of suffocation, may occur less often; this is called *the chokes*.

Itching may coexist, but swelling or discoloration never occurs. More or less shock generally coexists, so that the pulse is quickened, perspiration is profuse, and there may be nausea or vomiting.

Paralysis Grades.—This may be a monoplegia, hemiplegia, or paraplegia; the last is commonest and ordinarily the legs are most affected.

The onset will be sudden or gradual and may or may not be preceded by pain. Sensation is generally not totally abolished even when motor control is wholly absent. The *sphincters* may be involved and the reflexes may be altered; the reverse may also pertain. Shock usually coexists. Cases going on to lasting improvement begin to show recession of symptoms promptly, and in some instances recovery is brought about at once after recompression.

Hematomyelia, not unlike the ordinary traumatic type seen with fracture-dislocation of the spine, may occur, and cases that show little or no progress in six months generally end fatally from sepsis acquired from infection of the urinary tract or bed-sores. Unconsciousness never occurs in the spinal type.

Cerebral Type.—Vertigo Grades.—Ringing or roaring in the ears is an almost constant occurrence of changed air pressure. Passengers passing under the East River in the local subway and Long Island trains experience such sensations; similar experiences mark the journey to New Jersey in the tubes of the Pennsylvania and Hudson and Manhattan Railway Systems also. Nausea, staggering, vertigo, and vomiting may also occur when the pressure changes are greater and when the compression or decompresison is more marked; this form is commonly known as *the staggers*.

Coma Grades.—Unconsciousness may be moderate or severe, and when the latter occurs the outlook is grave.

Delirium may occur and the patient tosses about, endeavoring to clutch at the affected side of the brain in those cases associated with hemiplegia or paraplegia. In the semicomatose cases the patient can sometimes be aroused by irritation and may be able to stand with assistance, but vision is generally limited to ability to distinguish light from darkness. Marked shock also exists frequently.

Treatment.—*Prophylaxis* is important and applicants should be rigidly examined before being allowed to work in the locks. Cardiac, arterial, nephritic, respiratory, nasopharyngeal, and otitic defects are contra-indications to employment. The markedly alcoholic are bad risks, and the use of such stimulants should be limited as far as possible. Persons less than twenty or over forty-five years old should not ordinarily be employed. Men formerly working as "sand hogs" should not be re-employed without examination, especially if previously subjected to "bends," "chokes," or "staggers." Very few "sand hogs" are able to work constantly more than five years, and during that period re-examination every three months is advisable. A severe attack interdicts future employment.

Large organizations provide medical attendance in a specially constructed "hospital lock" at the scene of the work, and such a "lock" is thus described by Pelton: It consists of a horizontal cylinder made of $\frac{1}{2}$- to $\frac{3}{4}$-inch boiler iron, a good size being 25 feet long and 7 feet in diameter. It should be divided into two chambers by a partition in which is an air-tight door opening inward. The open end of the lock has a similar door. Both chambers are supplied with outlet and inlet valves, and then the patient can be visited without changing his pressure. Heating apparatus should be electric.

Rate of decompression is the main prophylactic factor, and danger is minimized when this is done gradually and when the men are urged to drink hot coffee freely, and emerge warmly clad.

Spinal cases usually respond promptly to recompression; that is, the patient is subjected rapidly to about two-thirds the pressure under which he was working when attacked. The duration of the recompression depends on its effects, and usually the symptoms subside after a few minutes of increased pressure. As soon as possible the patient is urged to stand or walk, and the circulation is further stimulated by deep breathing, forced muscle movements, or massage. The legs and arms are especially urged into action. Hypodermics of strychnin, caffein, camphor, or other heart stimulants may also be employed.

As soon as the symptoms subside, *decompression* may begin and the ordinary case is decompressed at the rate of 1 pound in four minutes, thus allowing one hour for 15 pounds pressure. In severer grades decompression should be much slower, and as much as ten minutes should be allowed for a reduction of 1 pound of pressure. Morphin may be needed occasionally for the pain.

If the attack occurs after the patient has left the scene of employment, recompression should be resorted to as promptly as possible; fortunately, such cases are generally not of severe grade. Patients suffering only pain go on to recovery spontaneously (Ryan). Exercise and forced activity, especially walking, is urged until the seizure subsides.

Where paralysis occurs and recompression is not available, massage, electricity, vibration, and forced movements are advisable; in many respects the necessity for this sort of activity resembles the treatment of opium-poisoning. If the sphincters are involved, suitable care must be provided. Cases showing early improvement recover completely as a rule; however, if the paralysis persists after recompression, it is likely to persist to some degree, and is later followed by atrophy and

a condition of ataxia or spasticity. The treatment of these cases is then like that of myelitis or peripheral neuritis.

Cerebral cases of the "staggers" variety are also recompressed, but this form of treatment is less valuable than in the preceding variety. Rest and quiet in a dark room are most beneficial. The attack gradually wears away, until at the end of a week the patient is on the way to recovery. Catheterization of the eustachian tubes with inflation of the middle ear is of service as well (Ryan). Stimulation is given hypodermically when needed. Artificial respiration, preferably by the aid of the pulmotor or lungmotor, is valuable. Oxygen may be of aid after the patient is out of the lock.

Injury from Illuminating Gas

Accidental inhalation of illuminating gas generally occurs from failure to fully turn off the stop-cocks of chandeliers or gas stoves, and from leaks in gas pipes or gas mains. Gas is commonly used as a means of suicide. Employees of gas companies and others continuously exposed are sometimes subject to so-called "chronic gas poisoning."

The lethal effects are primarily due to the irrespirable character of the inhalant.

The *carbon monoxid* present in gas is the determining poisonous element because it has an affinity for the hemoglobin of the blood three hundred times greater than oxygen. Fortunately the resultant carbon monoxid hemoglobin is relatively unstable and hence can be decomposed when oxygen is present in great excess, resulting in the formation of oxyhemoglobin. Under such conditions it appears that the carbon monoxid is expired as such and is not converted into carbon dioxid as formerly maintained.

Symptoms.—Ordinarily three stages are described, depending upon the (*a*) amount inspired, and (*b*) personal susceptibility. Obviously, the more concentrated the gas, the more rapid and severe the effects. Some individuals have a marked tolerance; others readily are affected by even slight amounts. The essential cause of symptoms is the diminution of oxygen leading to asphyxia.

First Stage.—Period of Excitement or Stimulation.—There will be evidences of *mental excitability* with perhaps giddy, irrational or delirious phases. Some *dyspnea* or respiratory embarassment generally is apparent. The *superficial veins* are generally prominent and *cyanosis* of moderate degree may exist. The *pupils* are usually quite widely

dilated. *Muscular twitching* may be marked. The *pulse* is slow and high tensioned. *Temperature* is normal. The breath and vomitus may be odorous of gas. Complaint is made of headache, weakness, and nausea, and there may be vomiting. *Prostration* and *langour* may be marked features. Irritation of the throat and bronchi may cause *coughing*.

Second Stage.—Period of Unconsciousness or Asphyxia.—The patient is *unconscious*, with *rapid, stertorous breathing*. The *pulse* is rapid and weak and the pressure is lowered. *Temperature* is elevated and not infrequently may reach 104° F. or more. In profound suffocation, control of the *sphincters* is lost. In later or more advanced stages *muscular rigidity*, especially of the jaws may occur.

The *pinkish* or characteristic *cherry red* blotches on the skin may appear. *Spectroscopic examination* will show the presence of carbon monoxid. The patient gradually shows increasing respiratory difficulty and Cheyne-Stokes respiration may ensue just before death.

Third Stage.—Period of Coma.—The patient has practically ceased to breathe, although the pulse is still perceptible, but cyanosis is marked. The pinkish or cherry red markings on the skin ordinarily are present, and muscular rigidity is marked.

The **duration** of the various stages is variable, and the passage from one period to another may not be appreciable; nor does a mild first stage indicate freedom from danger, as the transition to a graver condition may be very sudden and without premonition. The average individual is affected by two minutes' inhalation of moderately concentrated gas; persons found in the second or unconscious period are ordinarily dangerously affected. *The character of respiration is the best single index of the degree of poisoning, and if respiration is fairly well established the immediate danger is usually passed in an hour.*

Postmortem Findings.—The fingers and toes are rigidly extended and assume the attitude of tetany. Within a few hours the pathognomonic pinkish or cherry red skin blotches appear, if they are not already present. The internal organs, notably the liver and spleen, are deeply injected and show areas of minute scattered hemorrhage. Areas of softening may be found in the brain and spinal cord. The soluble blood is pink, and carbon monoxid is shown by the spectroscope. The *Hoppe-Seyler test*, demonstrating carbon monoxid in the blood, is performed by doubling its volume with a solution of sodium hydrate that yields a cherry red color when spread on porcelain; ordinary blood becomes brown or green under similar dilution.

Blood containing carbon monoxid does not turn scarlet on coming

in contact with the air; normal blood does present that hue from the formation of oxyhemoglobin.

Sequelæ.—Most of these are of nervous origin and chiefly relate to headache, irregularly distributed areas of pain, hyperesthesia, or anesthesia. Some patients are irrational or slightly delirious, and insomnia or tremors may appear. Laryngitis, bronchitis, and bronchopneumonia may occur. Less often there may be transient paralysis, glycosuria, and fever. Disturbances of the special senses (notably sight and hearing) and areas of gangrene are rare occurrences. Permanent after-effects are exceedingly rare, and the preceding sequelæ are generally present only in severer cases.

McCoombs, with 1000 cases in ten years' experience, states: "There have been individuals poisoned by illuminating gas who have been suffering at the time from chronic organic involvement of almost every description; many pregnant women are included in these statistics, also patients with tuberculosis and several who were in the midst of typhoid fever. None suffered any permanent bad effects and no miscarriages have occurred; the children when born have been normal. Sequelæ are more likely to occur in those of advanced years. . . ."

Other Forms of Illuminating Gas.—*Water-gas* is the sort ordinarily now in use for illumination.

Coal-gas, according to Remsen, contains 7.9 per cent. of carbon monoxid and a much less percentage of "illuminants" (ethylene, propylene, burylene, ethane, propane, butane) than water-gas. The latter contained 28.25 per cent. of carbon monoxid (Remsen), or 21.51 per cent. according to Lave.

Oil-gas is principally used to illuminate railway cars and is made after the "Pintsch process" by heating petroleum tar or shale oils in a retort to a temperature of 1000° C.; it is also used to enrich other gases of a low illuminating power (Bartley).

Treatment.—The essential need is to displace the carbon monoxid hemoglobin of the circulating blood by introducing oxygen so that the normal oxyhemoglobin may reappear.

First stage cases are given fresh air and such stimulants as whisky, aromatic spirits of ammonia, or others, as may be needed. Patients feel much better after they have "belched up the gas," and for that reason effervescent drinks are used; Vichy, seltzer, effervescent phosphate of soda, and other "fizzing" types of drinks are useful. Employees and others accustomed to such symptoms usually drink "weiss beer." If these milder measures do not relieve the nausea, headache, and other symptoms, inhalations of oxygen are used.

Caution is to be given the patient so that relapse or progression into another stage may be avoided. Most cases complain of nausea, headache, and weakness for a few days, and, if needed, appropriate treatment is given for these.

Second Stage.—Artificial respiration in the fresh air is generally needed until oxygen inhalations can be substituted. Stimulation by hypodermics of atropin, strychnin, caffein, or whisky are generally required. If shock is present, external heat is necessary. Massage of the limbs is useful. *Venesection* can be used in the plethoric. It may be combined with the injection of normal salt solution into a vein at the bend of the elbow. Direct *transfusion* of blood is advised by Crile and others; unfortunately, considerable surgical skill is necessary to successfully perform this, and a donor is not always available.

The recent introduction of the pulmotor and lungmotor afford valuable means of mechanically providing artificial respiration and the introduction of oxygen under pressure. This form of apparatus is partly automatic in action and it is said to force a large percentage of oxygen into the lungs under a constant pressure of five atmospheres (equal to a pressure of 75 pounds to the square inch), and is so adjusted that it accommodates itself to the lung capacity of the patient. I have seen it in action and have had it applied to myself while vainly trying to prevent it from forcing me to breathe with respiration withheld. Through the efforts of Dr. John Woodman, Medical Officer of the Edison Companies, the apparatus is now part of the equipment of the gas company repair shops, and is provided free of cost and sent by automobile on request to any case of gas-poisoning in New York. When obtainable, the pulmotor or lungmotor is a most efficient treatment, and if used early enough the vast majority of cases will be resuscitated. A tube introduced into the trachea (intratracheal insufflation method of Meltzer and others) through which oxygen is forced may be of value when combined with artificial respiration.

Third Stage.—The patient is breathing very little if at all. Artificial respiration must begin *at once* and continue in relays while oxygen is being introduced and stimulation is hypodermically administered. Transfusion of saline solution, with or without venesection, may be tried. If available, transfusion of blood may be performed. To be of service, treatment must be prompt and heroic. If obtainable, the pulmotor or lungmotor will probably save when all else fails. Intratracheal introduction of oxygen may be of service. The patient should

not be abandoned if the pulse can be felt, as cases of recovery are recorded after hours of suspended respiration.

Chronic Gas-poisoning.—Employees and others subjected to the more or less constant inhalation of gas are sometimes subject to headache, various neuralgic pains, anemia, muscular weakness, and gastro-intestinal disturbances. Blood examination shows in some an excess of red blood-corpuscles. Idiosyncrasy plays a great part because many employees are for years daily subjected to first stage degrees of poisoning and pay little or no attention to its symptoms.

Treatment.—This is obviously directed to removal of the source of irritation; this means usually new gas-piping or a new occupation. Anemia, gastro-intestinal, or other constitutional troubles are suitably cared for.

CHAPTER XVIII

INJURIES DUE TO SUBMERSION; TO SUFFOCATION; TO SMOKE INHALATION

Submersion; Drowning

Accidents of this sort are quite common and are the outcome of unintentional or intentional acts.

Submersion may be termed an early stage of drowning, and intermediate between the latter and **immersion.** In most instances the victim "falls overboard" or is overcome by "cramps" or fatigue while bathing, and when rescued is more or less unconscious, pallid or livid, limp, cold, and suffering from other signs of shock. Considerable water has been swallowed and the abdomen is usually distended and tense, and this is an added element in the respiratory difficulty. These patients are always breathing and the radial pulse is present, although cardiac and respiratory action may be very feeble.

Treatment is practically that of shock, although profound manifestations require artificial respiration. Hypodermics of whisky, strychnin, caffein, or camphor are indicated, and the patient is put to bed surrounded by hot bags or bottles until reaction is established. Some cases respond best to *rectal stimulation* afforded by the introduction of a pint of normal salt solution or ordinary tap-water (at a temperature of 110 ° F.) containing 4 to 8 ounces of whisky. The continuous rectal instillation of saline solution or plain water by the "drop method" is also valuable.

Drowning is always associated with unconsciousness, and the patient breathes only occasionally or not at all, the cardiac impulse is heard with difficulty, and a pulsation in the neck or at the wrist is rarely obtainable in marked cases; in effect, the vital processes are temporarily suspended. The patient is pale or livid, limp, cold, and occasionally may audibly or visibly gasp. Involuntary escape of urine or feces is frequent. Water may run out of the mouth and nose. The eyes are usually closed; if open, they are lusterless and staring.

Treatment comprises (1) stimulation and (2) artificial respiration.

(1) *Stimulation* is by hypodermics of such cardiac and respiratory stimulants as were named in the treatment of Submersion. An excellent emergency stimulant is to dilate the rectum by the fingers; occasionally vigorous massage or slapping over the precordial region is also effective.

(2) *Artificial respiration* is preceded by efforts to remove water that

may overflow from the mouth, and to that end the head is lowered and the upper abdomen and chest compressed. The patient is then subjected to the manipulations of the "Sylvester method of artificial respiration," care being exercised to have the shoulders supported so that the head falls back enough to put the neck on the stretch. The tongue must not be allowed to drop over the epiglottis, and to pre-

Fig. 513.—Inspiration; pressure off.

vent this a scarf or other pin or a thread may be put through one side of the tongue so that it always is held forward. The "Schäfer method of artificial respiration" or "prone pressure method" is now somewhat more popular and is sufficiently indicated by Figs. 513 and 514.

Fig. 514.—Expiration; pressure on.

Irrespective of the method chosen, the rate of the manipulations is such that respirations of 14 to 18 per minute are carried on. Death must not be conceded until such efforts have been vainly employed for at least three-quarters of an hour. Respiration once spontaneously reëstablished is likely to continue, but provision must be made for careful watch over the patient until consciousness is wholly restored.

The pulmotor and lungmotor are especially efficient mechanical agents in performing artificial respiration, and they may save life where manual means would fail.

A tube introduced into the trachea and attached to a bellows may provide a useful emergency method of intratracheal insufflation after the Meltzer-Auer method.

Sequelæ like pneumonia, nephritis, or delirium tremens are relatively common, and these usually appear within the first three days, if at all.

Suffocation; Smoke Inhalation

When a person is overcome by inspiring smoke, fumes, or irritating vapors the condition is practically one of unconsciousness with symptoms not unlike those due to cardiac and respiratory failure from a variety of other causes, such as gas-poisoning, drowning, or profound electric shock. Firemen and occupants of burning buildings are the usual victims, and all degrees of smoke-prostration are encountered.

Mild forms are characterized by coughing, lacrimation, and a mucous nasal discharge, accompanied often by much redness of the eyes and dryness of the lips and mouth.

Moderate forms manifest the preceding symptoms, with headache, ringing or roaring in the ears, dizziness, nausea, vomiting, and mild syncopal tendencies.

Severe forms are preceded by initial symptoms of the foregoing type, with unconsciousness as a terminal manifestation. Such a person is livid, the face is puffed, the body rigid, and there may be involuntary defecation or urination.

Treatment is summated by the terms "fresh air," "cardiac and respiratory stimulants," and "artificial respiration," either manual or mechanical. The inhalation of fumes from vinegar is a valuable adjunct in cases that are recovering, and another favorite remedy with firemen is birch beer, because the effervescing and "taste-repeating" qualities of this drink effectively "take the smoke out of the system."

In a recent accident in the local subway due to a short circuit numerous passengers were overcome by smoke arising from the burning insulation of feed wires. Most of the patients vomited and had headache and signs of laryngobronchitis; practically all of the cases recovered within a few days.

Sequelæ like pneumonia and gastro-intestinal disturbances are relatively common in the most severe cases.

In case of death the respiratory tract shows evidences of considerable engorgement and patches of bronchopneumonia.

CHAPTER XIX

INJURY IN RELATION TO ABORTIONS, APPENDICITIS, VISCERAL PROLAPSE

Abortions and Miscarriages

These are frequently more or less reliably connected with accident and injury, and are often the subject of medicolegal importance.

Interruption of pregnancy is generally classified by the terms:

(1) *Abortion*: Interruption of pregnancy prior to the fourth month.

(2) *Miscarriage:* Interruption of pregnancy prior to the eighth month.

(3) *Premature birth:* Interruption of pregnancy after the eighth month and prior to full term, namely, two hundred and eighty days, or ten lunar or nine calendar months.

Varieties.—An abortion or miscarriage can be—

(*a*) *Complete*, in which the fetus is expelled intact with the membranes unseparated.

(*b*) *Incomplete*, in which the fetus and membranes are separated, more or less of the latter remaining in the uterus; this is the common variety.

(*c*) *Spontaneous*, in which the occurrence is unprovoked by drugs, instrumentation, or other interference.

(*d*) *Induced*, in which the interruption is brought about designedly by any of several abortifacients.

(*e*) *Concealed*, in which the fetus dies *in utero* and remains there for days, weeks, or months; this variety is clinically so rare that it is negligible.

Frequency.—Obviously, statistics are unreliable as to abortions and miscarriages in general, but of 10,000 representative cases of pregnancy collected by Edgar and cited in his work on *Obstetrics*, it appears that 635 were interrupted pregnancies, distributed as follows:

242 were abortions (before fourth month);

175 were miscarriages (before eighth month);

218 were premature births (before tenth month).

Stated in other language, these figures indicate that there was 1 abortion in every 41.3 labors; 1 miscarriage in every 57.1 labors; 1 premature birth in every 45.8 labors. This, summed up, means that for

every 15.7 labors there was one interrupted pregnancy of some form. Most authorities hold that the vast majority of women abort once or more during their child-bearing period.

Multiparæ are most prone to interrupted pregnancies, and Edgar quotes the following statistics based on the same series of 10,000 cases:

Number of pregnancy.	Abortions.	Miscarriages.	Premature births.	Interrupted, total.	Full term.	All.
First	29	22	71	122	2009	2131
Second, third, fourth, fifth	120	94	97	311	5202	5513
Beyond fifth	79	49	46	174	2047	2221
Unknown	14	10	4	28	107	135
Total	242	175	218	635	9365	10,000

There are certain months in which these mishaps are most likely to occur, and Edgar states the following as to this feature:

Third	month	23.9	per cent.	interrupted	before term.
Fourth	"	11.18	"	"	" "
Fifth	"	6.93	"	"	" "
Sixth	"	6.15	"	"	" "
Seventh	"	9.60	"	"	" "
Eighth	"	12.63	"	"	" "
Ninth	"	12.25	"	"	" "

Manifestly figures for the first and second month of pregnancy are not very reliable, because so many women "skip a period" without being pregnant, and hence the author above quoted begins his statistics with the third month.

Some women have interruption of pregnancy so often that they are said to have the "miscarriage habit," and figures indicate that each subsequent miscarriage occurs a little earlier than the one preceding.

Causes.—These are numerous, and may be maternal, paternal, or fetal. Of the great number of possible factors, Edgar gives the following as the most common: Endometritis; retrodisplacements, with or without adhesions; syphilis; nephritis; intentional or criminal interference; low placental attachment.

Relation of Trauma.—There is apparently an individual susceptibility in relation to accidents and injuries as a producing cause, for some women are unaffected by the gravest injuries and others claim to abort or miscarry on the receipt of many trivial psychic or physical violence. My personal observation is that most of the so-called traumatic cases occur in the early periods of gestation, usually at the third or fifth months. The majority of them, strange as it may appear, are not incidental to grave injuries, but, on the contrary, are quite regularly associated with rather trifling injuries, and not a few are ascribed

wholly to "fright" or "shock." It is exceedingly rare to have any hospital patient blame the mishap on any other cause than "strain," "lifting," "falling," or some emotional upset; and, indeed, this is the history usually given by private patients as well.

It is a common experience to have a woman deny interference by an abortionist even though death is imminent from septic infection. This sort of secrecy on the part of the patient is so well known that reputable physicians usually call in a confrère before operating upon a case of interrupted pregnancy so that there may be a witness to the narrated cause of the occurrence, and also as to the operative findings. Certainly it is the experience of most hospital surgeons that abortions and miscarriages are very rare complications of actual injury, and that such an alleged sole cause is at least open to some suspicion.

If an injury is to play any part in the matter, the symptoms should appear very promptly, and if there is a lapse of more than a few hours, other factors should be looked for as at least contributory if not wholly causative. There are some few cases in which symptoms are slight or sharp at first and then progress or recede; but the usual rule is, as stated by Edgar, for the whole process to be finished in from twenty-four to thirty-six hours, irrespective of the asserted cause. In other words, from the onset of symptoms until the expulsion of the ovum or fetus there are some symptoms indicating that interruption is threatened or actually under way.

Symptoms.—In cases of *threatened* abortion or miscarriage the initial symptom is abdominal *pain*, which is usually of a cramp-like or colicky variety, and which is associated with some *nausea* or *vomiting*, and perhaps also with *dizziness* or *vertigo*. *Vaginal bleeding* may be of the *spotting* variety or in quantity sufficient to soil the clothing. It usually does not last long and is generally associated with the abdominal pain.

Vaginal examination at this time shows the cervix to be soft, open at the tip, and blood or clots will be found at the external os; the enlarged uterus is likely to be tender and perhaps boggy in certain areas.

If due to injury, the onset of these signs is reasonably prompt, usually within a few hours, thus occurring at a time when the effects of the accident are at the maximum; if there is an interval of more than thirty hours after the accident without any signs of interrupted pregnancy, then the accident can rarely be looked upon as the sole producing factor.

In *inevitable* abortion or miscarriage, the abdominal pain and the bleeding are more severe and continuous, and there is practically no

cessation of symptoms until the uterus empties itself completely. Most of these patients bleed so much that an acute anemia is produced, and marked shock is often in evidence and fainting may occur.

In the interruptions of early pregnancy the pain and bleeding are less marked than in later pregnancy, and after the third month the symptoms simulate those of full term labor.

Any vaginal examination made more than three weeks after a mishap may fail to show any recent uterine enlargement; but investigation prior to that time will give indications either in the vagina, cervix or uterus, and perhaps also in the breasts.

Differential diagnosis in the early periods must be made between *menstruation*, *ectopic pregnancy*, *neoplasms* (notably polypoid and fibroid growths), and *adnexal disease*. The distinction is best made by vaginal examination and the external evidences shown by the breasts and abdominal markings. It is to be remembered also that the external genitals and the cervix of a pregnant woman present rather typical manifestations of pregnancy. The Abderhalden test may also prove confirmative in some cases.

Treatment.—*Threatened forms* are treated by absolute rest, elevation of the foot of the bed, an ice-bag over the abdomen, and sedatives, such as morphin or other derivatives of opium. Packing the vagina with gauze or cotton will invite uterine contractions and thus promote rather than prevent the event.

Inevitable forms require the same treatment, except that packing the vagina finds more indications. After expulsion of the ovum or fetus, curetage should be done if there is any doubt at all that some of the conception products are retained. An anesthetic is often unnecessary, but strict asepsis must be practised, and the uterus should not be regarded as really clean until it becomes hard or much smaller.

After-treatment consists of a daily saline douche and a stay in bed of five days or a week. Ergot, pituitrin, and drugs of that class may sometimes become necessary. The uterus must be put into the normal forward position and kept there by a pessary or tampon if it has sagged or become tilted backward. Cases improperly treated or neglected usually furnish the examples of subinvolution, and these are often associated with adnexal disease, and this combination may require curetage and perhaps other operative care. Sepsis and like inflammatory complications nearly always indicate criminal interference or unclean personal or surgical attention.

An uninduced uncomplicated abortion or miscarriage should leave the genital organs in practically a normal condition after a month.

Traumatic Appendicitis

It is sometimes asserted that an attack of appendicitis is induced by continued pressure, or a blow, fall, or other violence upon the abdomen, and such an origin is then made the basis for a claim against an employer or insurance company, or a suit is brought against some defendant.

In other words, this contention is practically limited to medicolegal exigencies, and it is discussed with that in view and not because it is clinically even an admitted occasional etiologic factor.

Perhaps half a dozen such claimants have been examined by me, but I never clinically saw or operated upon a case of traumatic appendicitis and do not know of any form of external violence capable of inducing it in a healthy appendix. That it may awaken a dormant appendicitis and produce a recurrent attack, seems remotely possible in certain forms of circumscribed violence, and in some more or less constantly inflamed, relatively superficial, or "ripe" appendices. That abscess formation or a gangrenous process is aided or abetted by external violence I do not believe.

There is only one case on record, so far as I know, that apparently is a real example of "traumatic appendicitis," and this was reported by Robert T. Morris as occurring in a physician who swallowed some glass and within a few days that same fragment of glass was removed from his appendix. Occasionally foreign bodies, like pins, seeds, and pits, are found in an appendix, but that they induce the attacks is exceedingly doubtful.

If *external violence* is to play any causative part whatever, the following factors must be in evidence:

(*a*) The *trauma* must be over the appendicular region, relatively circumscribed, and severe enough to give immediate abdominal pain and external evidences of injury.

(*b*) The *onset* of symptoms must be reasonably prompt, and from the receipt of the violence to the development of diagnostic evidences of appendicular trouble, the interval must be filled by manifestations of some intra-abdominal disturbance.

(*c*) The *attack* must be the first that ever occurred, because recurrent attacks arise so commonly from a variety of causes that any injury would probably only act as an incident or coincidence.

(*d*) There must be no *preceding history* of "indigestion," "biliousness," "colic," or "ptomain poisoning," for any of these may be actually, and often do mean, appendicitis.

(*e*) At *operation* the appendix should be found acutely inflamed,

with perhaps some evidences of hematoma on or in it. No adhesions within or without should exist; and membranes, veils, bands, or lesions of the adjacent intestines or viscera usually mean chronicity or recurrence.

(*f*) *Pathologically*, on gross examination, there should be no fibroid, strictural, or other indications of an ancient process, and microscopically no changes of a similar sort should be apparent.

From a practical standpoint it seems highly improbable that any sort of violence could produce a lesion of this deep-seated, movable, and well-protected tiny piece of intestine and yet do no damage to surrounding intestine nearer the source of violence and far more vulnerable. Further, abdominal injury may effect almost any of the contained viscera most seriously, but as yet no case of direct injury to the appendix has been authenticated, either as an isolated or associated lesion.

There is a perfectly good, adequate, and well-established cause for every case of appendicitis, and it is thus exceedingly hard to rank trauma as even a remotely possible etiologic element. I have known patients to have "pain in the appendix region" after diving, straining, lifting, coughing, climbing and doing a variety of movements that cause the lower abdominal and upper thigh muscles to contract; but all of these patients previously had symptoms more or less marked that denoted the possession of a "grumpy" appendix that would "growl" at many forms of external as well as internal irritation.

Sprengel,[1] quoted by DaCosta, says that there is no recorded case of scientifically proved traumatic appendicitis. John B. Deaver in his article on this topic is of the same opinion. Personally, I see no more relation between a blow on the abdomen and appendicitis than between a blow on the abdomen and typhoid fever, or a blow on the neck and tonsillitis.

The worst that abdominal violence can do is apparently to act very occasionally as an alarm clock for an appendix that was a little tardy in re-awakening, but which would probably "get up" more promptly at a signal from an overloaded stomach or colon, or from the immigration of bacteria from a more or less distant focus.

Relation of Injury to Visceral Prolapse

The traumatic origin of herniæ and displacement of the kidney, uterus, and other organs is a matter of frequent medicolegal, casualty, and compensation law importance. Strictly speaking, visceroptosis,

[1] *Deut. Med. Woch.*, December, 1911.

or the displacement of any organ, is, in a broad sense, a "hernia," and for that reason there are certain determining elements common to all displacements of abdominal viscera.

In order of frequency, traumatic origin is sometimes claimed for displacement of the uterus, kidney, or gastro-intestinal organs.

Traumatic Hernia

Inguinal, umbilical, and femoral herniæ are often said to have developed as the sole result of an injury, and this source of origin is generally accepted by the laity, who, in turn, learned of it from physicians who as a class formerly entertained similar views as to its causation.

Inguinal Hernia or Rupture.—It has been stated that 1 in every 30 males has an inguinal hernia, this having been ascertained by military, insurance, and other statistics. It is equally well known that a rupture may for a long time exist unknown to the possessor, and if any symptoms arise, they are often ascribed to a variety of other causes until the true origin is demonstrated by examination.

Anatomy.—It will be recalled that the lower abdomen has no main communication with the outside parts except by way of a canal leading from the bladder, rectum, and uterus respectively; or by a spermatic cord or round ligament or vessels escaping from a guarded abdominal orifice. Structurally, then, there are few places predisposed to give way under the strain from within, but of the available weak spots, the inguinal region is one of the most vulnerable.

Normally, the oval opening of the *internal abdominal ring* is a little larger than an ordinary lead pencil, and it lies midway between the *anterior superior spine of the ilium* and the *spine of the pubis*. It leads to the *inguinal canal*, which is about $2\frac{1}{2}$ inches long, reaching almost to the pubic spine and ending in the *external abdominal ring*. Along this route or canal an inguinal hernia passes if it is of the ordinary *oblique* or *indirect* variety; if it pushes right through the canal, without first entering the internal ring, then it is of the *vertical* or *direct* variety. Very strong interlaced and tightly bound muscles and fascia protect this region and it abounds in blood-vessels and nerves; thus it is strong and sensitive.

The traumatic theory of origin asserts that some form of extreme violence (direct, usually, but often indirect) is capable of suddenly causing these natural barriers to stretch or break, thus allowing the protrusion of gut or omentum, or both.

At one time "trauma," used in a very general sense, was supposed

to be the essential cause of hernia, but of late this idea has been practically abandoned, and the prevailing view is that a hernia is of a gradual development and that a preformed sac or pouch of peritoneum is almost invariably present. There is a strong congenital cause for hernia and it is well recognized that a marked family tendency to the condition exists.

It seems strange that a fully formed hernia could be suspected of developing from a single act of trauma in view of the anatomic and surgical structural formation. This is brought out very prominently during the progress of a herniotomy, and no operating surgeon would maintain that an internal ring could be by one act of violence suddenly stretched enough to allow a portion of the abdominal contents to escape and then equally suddenly dilate the inguinal canal, and perhaps traverse it and even reach the scrotum; such an occurrence inevitably would lacerate the protruding part and cause marked shock and probably hemorrhage also. In the hernia operation it is often quite difficult to introduce an ordinary grooved director (less than one-half the diameter of a lead pencil) along the already dilated canal from the external to the internal ring; if this is so in an anesthetized patient with the parts already stretched by the passage of a hernia, how much more difficult must it be for a richly sensitized piece of intestine or omentum to traverse a much more protected and previously normal route?

Causes.—The sources of origin are usually divided into (*a*) congenital or predisposing, and (*b*) acquired or exciting.

(*a*) *Congenital* or *predisposing* elements are structural and anatomic and presuppose that the normal barriers (rings, canals, muscles, fascia, vessels, peritoneum, intestine, or omentum) are abnormal in formation or inadequate in strength or resistance. As stated, there is a marked family tendency notably on the male side, and it is well known that children are quite prone to present herniæ in connection with hydrocele and other congenital or early acquired defects.

(*b*) *Acquired* or *exciting* elements can all be grouped under the one essential factor of *intra-abdominal strain* or *pressure*, and of these may be cited:

(1) *Occupation* calling for effort in which the abdominal muscles are caused to contract so that the abdominal contents are forced downward and forward. Lifting, pushing, hauling, bending, and twisting motions, if persistent, may eventually produce a hernia in any individual presenting relaxed rings or other abnormal safeguards. Certain occupations are particularly liable to act as excitants, such as those of laborers, teamsters, chauffeurs, piano-movers, and others whose daily

work requires a maximum of pushing, pulling, lifting, and carrying. Work that requires prolonged standing or walking may also be causative.

(2) *Coughing*, *sneezing*, *vomiting*, and allied acts may be productive because of their persistency or severity, especially if accompanied by muscular weakness lowering the resistance of the normal supports. Whooping-cough, bronchitis, and gastro-intestinal ailments are thus often responsible.

(3) *Muscular relaxation* due to pregnancy, tumors, ascites, visceral displacement, or operations are important factors because atonicity is a very essential element, notably when it becomes more or less general with the advance of years or is an associate of prolonged or exhausting disease. The enteroptosis and sagging abdominal wall of the old person is very familiar, and in women especially it is often found in association with hernia and displacement of pelvic viscera. Likewise, too much or too little fat may produce muscular weakness and thus cause hernia.

(4) *Trauma* is the rarest of all causes and no single or isolated act of ordinary violence has ever produced a fully formed hernia. Bull and Coley investigated the alleged relation of injury to hernia, and of 10,000 cases at the Ruptured and Crippled Hospital only 2 stood in a causal relationship. One of these was a man gored by a bull and the other was caused by equally direct violence. This question has also been investigated by Outten, Sultan, and many others, and the consensus of opinion is against any such long entertained belief. The writer has never seen a genuine traumatic hernia due to a non-penetrating accident, and he knows of no well authenticated cases of acute rupture, even though the associated injuries were of such a nature as to greatly damage parts likely to be herniated.

This inability to show any relationship is very remarkable in view of the fact that nearly all patients give the surgeon a history of injury and look upon the latter as the ascribable cause.

Direct or vertical hernia, in which the protrusion is directly into the canal without passing first through the internal ring, is naturally much more likely to be traumatic than the indirect or oblique variety. In this connection it is very suggestive that if injury was such an important causative agent, then *direct* should be much more common than *indirect* hernia, but this is not true, as the former occurs only in from 3 to 5 per cent. of cases.

At one time *any* sort of violence was looked upon as productive, but manifestly *indirect* violence can play no part, as the impacting

force would be expended long before the inguinal region was reached. Falls on the extremities, back, buttocks, and elsewhere were supposed to "jar the abdominal contents" so that a loop of gut or piece of omentum would extrude; but at the present time focal or direct injury of the abdominal wall or region of the subsequent hernia is the only sort of injury given consideration as a possible factor.

Of course, any penetrating wound that sufficiently cuts the muscles or other retaining parts is excepted in this discussion, as any hernia then resulting is practically of the postoperative variety.

Given a case of alleged posttraumatic hernia, the following factors are to be considered by the examiner in determining what relation, if any, the accident bears to it:

History of the Case.—The manner of the *accident* and the immediate and subsequent *symptoms* are very important. If the violence has been ordinary and if the main force of the impact has been distant from the herniated zone, then, obviously, the relationship cannot be close. If, however, the impact has been to the abdominal wall or region of the hernia, then the associated findings need greater consideration. This is especially true if the abdomen has been squeezed or jammed (as between a moving and stationary object, or moving objects) or where there has been a direct impinging against a relatively small area close to the hernia (as a fall against a sharp projection, or a blow from a small moving object).

The immediate symptoms should be pain, nausea, and perhaps also vomiting and bloody stools, together with a considerable degree of shock; in a word, some of the well-known evidences of internal abdominal injury should be present, for the damage done has been great enough to produce considerable systemic disturbance. Later should follow ecchymosis, swelling, and tenderness localized over the region of the hernia. The recognition of an actual rupture may for a few days be obscured by a hematoma, but the earlier the hernia actually appears, the greater the possible relationship to the accident. Hematoma of the vulva or scrotum are often mistaken for hernia; and it is well known that both sexes often show sausage-shaped inguinal swellings after abdominal contusion, and these also are at first hard to differentiate. After the first few days the exact location, size, and extent of the protrusion are determinable, but in the interval and from the very inception of the violence the patient will complain of pain increased by motion or pressure and perhaps also have pain at stool or during micturition. The ecchymosis and local pain may persist a fortnight or more; and if the former has been extensive, it may also diffuse into

contiguous but distant parts, and may even appear in the middle of the thigh or mid-abdomen and near the iliac crests.

The condition now being definitely determined, the question arises as to its age, and this can be ordinarily ascertained by the *size*, *location*, and *general appearance*. If small, tender, and at or near the internal ring, the greater the possibility of recent origin. Likewise, an irregular, tight, and tender ring, with inability to easily reduce and reproduce the mass, speak for recency. It is to be remembered in this connection that in many persons an impulse can be obtained with a finger-tip in the canal; but the United States Pension and other official agencies do not regard this of itself as indicative of hernia. Ancient origin is denoted by absence of ecchymosis and the large size (bigger than an almond after the lapse of a few weeks); the laxity and regularity of the ring (admitting more than one finger-tip); the presence of thickening or other signs of pressure; dermatitis from tension within or without; the absence of pigment or hair as from a truss; general thickening of the parts; easy reducibility and reproduction; freedom from pain on manipulation and the capacity of the patient to accommodate his movements to the swelling; general laxity of the involved or adjacent muscles; bilaterality or other herniæ; associated varicocele, hydrocele, or other abnormalities.

Scrotal herniæ take a long time to form and are never seen within a few weeks of any alleged causative factor. The type of contents within the sac offers little clue, as this may be wholly intestinal or omental, or both combined.

A previously existing hernia, bruised or otherwise irritated by injury, may become inflamed and thus in the early stages simulate a recent hernia; but after a few days the differentiation should present no difficulties.

Non-traumatic hernia is often bilateral; traumatic hernia never is. Ordinary hernia is usually left-sided; traumatic hernia is near the seat of injury.

The surgeon may also be sometimes called upon to express an opinion as to what influence, if any, an accident has had in *aggravating* or *increasing an already existing hernia*. Often when an accident occurs, or if the patient receives a "strain," self-examination may disclose a hernia which naturally enough is charged to the occurrence in question; or the condition is found by a physician and the same view is entertained even though the "lump" may have long existed unknown to its possessor. If further analysis indicates that the accident was not the producing, then it may have been the aggravating, factor.

Sudden increase of intra-abdominal pressure can still further propel a pre-existing hernia along its route; and such forms of pressure may sometimes act sufficiently promptly to bring into immediate view a mass that eventually would independently appear because of the more gradual and steady push of factors that had been operative perhaps since birth.

In this respect the inguinal route can be likened to the parturient route in which the internal ring represents the internal os; the inguinal canal is like the cervical canal; and the external os is like the external ring. The propelling forces in both act slowly until the intra-abdominal contents are born, and thus the *vis a tergo* in pregnancy and hernia alike is effective only by a *continuing process* of forcible gradual dilatation. This means that a hernia once started will eventually fully develop unless checked by treatment; but the rapidity of growth is indeterminable, depending mainly on the age, physique, and occupation of the individual. In other words, if the structural conditions are right and the necessary intra-abdominal "push" is present, then a hernia can always be said to be "viable" or "nascent."

Sudden increase in the size of any rupture is not uncommon if the parts are lax, and even an attack of sneezing or coughing or simple straining may be enough if the conditions are ripe. An accident may act in the same way if it is *adequate*, and this element, together with the extent of increase and the symptoms from it, determine to what degree, if any, a given injury is responsible for still further propelling a hernia.

The element of *adequacy* is present if intra-abdominal pressure has been caused by violence of such an extent that added protrusion could be reasonably expected to follow.

The *increase* in size likely to occur is naturally dependent upon the degree of violence and the type of person, and the site and kind of the rupture. At best the enlargement cannot be very great and rarely can it cause an increase of more than one-fourth the original size, and nearly always the mass has been previously at or beyond the external ring. Omental are more likely than intestinal contents to sudden increase in size; and atonic muscles, more likely to further relax than the firm and strong.

Symptoms necessarily exist, and these are usually in the nature of pain, swelling, tenderness, and ecchymosis. A recently enlarged hernia is obviously harder to replace than formerly, and the kind and degree of manipulation differs from that needed when the rupture was stationary in site and size.

Irreducible or incarcerated herniæ obviously are less likely to be affected by external causes than reducible or more or less "free" herniæ. Those retained by properly fitting trusses also are not so subject to changes in size. Poorly fitted trusses often aggravate conditions because they squeeze or inflame the herniated mass and push part of it out instead of holding all of it in.

The relation of injury to *strangulation* of a previous hernia is sometimes apparent when the accident is of such a nature that intra-abdominal pressure has been increased and when the strangulation develops within a very short time (usually immediately) after the trauma.

Herniæ, unsupported, inevitably increase in size and are never spontaneously cured in working adults.

Umbilical Herniæ.—These navel ruptures usually occur in fat persons, especially women. Pregnancy, tumors, ascites, and other causes for intra-abdominal strain are the usual producing factors. They may exist a very long time without causing symptoms, and hence the possessor often knows nothing of their existence. Their origin is essentially dependent upon structural deficiency and slow increase of intra-abdominal pressure or strain. Many of them are congenital and they are quite common in infancy. They all are of very slow growth up to a certain period, and then may suddenly undergo quite a marked increase in size as they become subcutaneous. Usually they are omental in type, but occasionally contain intestine also. They are prone to be irreducible because adhesions readily form between the contents and the sac, or the latter attaches itself to neighboring soft parts. Every operating surgeon is impressed by the fact of their ancient origin from the very firm attachment they uniformly present to the adjacent parts, and by the wide separation and atrophy they produce in the rectus and other muscles by long continued pressure.

Injury never is the sole producing factor, and no accident is responsible for their increase or aggravation unless considerable intra-abdominal pressure has been occasioned, and under such circumstances signs of abdominal shock, local pain, ecchymosis, tenderness, and rigidity promptly appear.

The relation of injury to *strangulation* is the same as in inguinal forms.

Femoral hernia occurs much more often in women, and is the outgrowth also of structural defects and prolonged pressure from above and within. It bears the same relation to injury as the preceding forms.

Lumbar, obturator, and other rare forms are never looked upon

as traumatic unless there has been actual laceration of muscles by penetrating wounds.

Postoperative Herniæ.—These are quite common after abdominal operations, especially where drainage has been used, notably if the incision has been at or near the midline of the lower abdomen, as for appendicitis, intestinal, pelvic, or urinary lesions. Incisions that split and do not cut muscles or fascia are least likely to cause hernia, especially in "clean" cases where no drainage has been used. The lateral muscle-splitting incisions (like McBurney's "gridiron") are less prone to hernia than vertical or transverse incisions.

Fig. 515.—Hernia of Petit's triangle following extensive wound over crest of ilium (rear and front views).

The essential cause for their development is intra-abdominal pressure acting upon (1) a weak scar due to the operative severing of the nerve supply to the abdominal muscles; or (2) the relaxed condition of the muscles due to prolonged illness; or (3) imperfect or inadequate operative technic. Most postoperative herniæ occur within the first six months, and for that reason many surgeons require the patient to wear an abdominal belt and refrain from lifting, straining, or otherwise increasing intra-abdominal tension in that interval. A rupture of this type rarely involves more than a portion of the scar at first, and, indeed, may appear only lateral to it near a stitch-hole or a slit in a muscular or fascial strand. The giving way prematurely of a buried stitch may be the starting-point, and gradually the process goes on

until a bulging appears on standing or effort. Sudden increase may spontaneously occur when the hernia is sufficiently developed to appear subcutaneously, thus indicating that the intervening barriers have been gradually stretched until they no longer possess any resistance.

Injury is never the sole initiating element in such a rupture, and may contribute to it as an exciting agent only when it has caused intra-abdominal tension adequate enough to induce acute symptoms allied to abdominal shock.

A patient of mine was caught between a moving subway train and the platform and received a long wound over the crest of the ilium, and a hernia through Petit's triangle subsequently developed in the scar of this wound, thus constituting a true traumatic postoperative hernia (Fig. 515).

Summary.—For an accident to be related to the subsequent development of any variety of hernia the following factors are needed:

(1) No previous hernia existed, as determined by definite prior examination.

(2) The parts are anatomically sound.

(3) The injury must have been close to the herniated zone.

(4) The violence must have been adequate.

(5) The symptoms must be of the type seen in abdominal shock with appropriate local signs (pain, swelling, ecchymosis, etc.).

(6) The hernia must appear very promptly; after two weeks it is often impossible to say just how long ago it has existed.

(7) No signs of old origin must exist.

(8) No other hernia on the opposite side or elsewhere must be in evidence, thus ruling out the so-called "herniæ tendency."

Uterine Displacement

External violence is sometimes looked upon as a source of origin in displacement of the pelvic viscera.

Backward displacement of the womb (*retroversion* or *retroflexion*) is the usual malposition alleged in accident cases, and it may or may not be claimed to exist with *prolapsus* also.

Forward displacements (*anteversion* or *anteflexion*) are rarely claimed as the outcome of an accident. Ovarian and tubal displacements are also infrequently alleged.

Anatomy.—The pear-sized and shaped uterus is placed in probably the most protected portion of the body, apparently a provision on the part of nature to propagate the race. The average virginal size of the organ is about 3 inches long and 2 inches broad, the wide upper end

tapering to about 1 inch at the cervix. After pregnancy some permanent enlargement is the rule. The womb in the virgin state usually weighs between 1½ and 2 ounces. It lies deep in the bony box of the pelvis and is protected in *front* by the strong abdominal wall and the bladder, the latter acting as a hydraulic bumper. *Behind* it is protected by a large mass of intestines and the bony bulwark of the lower end of the spinal column and the thick buttocks. *Laterally* the flaring wings of the bony pelvis guard it, together with the intestines. Thus it is practically suspended in the bottom of a bony box and surrounded on all sides by buffers of a fluid, semifluid, or gaseous consistency. It is so inaccessible that when the abdomen is opened, it is necessary to push aside the intestines or bladder in order to view or feel it, and thus uterine operations are performed with the patient's hips much higher than the head so that the intestines may gravitate toward the diaphragm ("Trendelenburg position").

The *normal axis* or *position* of the uterus is one of *anteversion*, so that it lies at an angle of between 65 and 85 degrees to the abdominal wall; this is about the angle that the hand makes to the forearm when the wrist is bent backward as far as possible. It is maintained in this position by a variety of factors such as the dynamic force of intra-abdominal pressure from surrounding contents, the guy-rope pull of elastic ligaments, and the supporting power of the intact fasciæ and perineum.

Uterine ligaments (or accessory peritoneal folds) are eight in number, so arranged that they accommodate the organ to the daily changes of intra-abdominal pressure. The large pair of *broad ligaments* pass from either side of the organ like bat-wings and become attached to the lateral walls and floor of the pelvis, embracing in their folds the ovaries and fallopian tubes. The two *round ligaments* pass from the upper front portion of the organ forward and outward and escape from the abdomen through the internal abdominal rings.

The two *uterosacral* ligaments pass backward to the sacrum. The two *uterovesical* ligaments pass laterally and forward.

Normally, the organ is very movable, and it can be pulled in all directions quite freely and will resume the normal position as soon as tension is relieved. However, if the pressure or abnormal displacement is continuous or nearly so, the ligaments become permanently stretched or lax and then the organ assumes some malposition. This is especially true if the normal supports are weakened from a variety of long or slowly acting causes, especially those leading to actual sagging or tearing, like enteroptosis and pregnancy.

Backward Displacement.—In this form the organ is tilted backward so that the fundus (roof) is turned to the rear, constituting *retroversion.* If the junction between the body of the organ and the cervix forms a kink or angle, then we denominate it as *retroflexion* (Fig. 516).

Causes.—The rearward position may be entirely normal, as it is estimated that about 20 per cent. of women are born with the organ in a backward rather than forward position; this is sometimes referred to as *congenital retrodisplacement* and it is entirely compatible with perfect health and function, and usually is unknown to the possessor until discovered by examination.

Acquired retrodisplacement is the outgrowth of any cause or set of causes that upset the mechanics of the lower abdomen; in other words,

Fig. 516.—Uterine displacement, black line indicating the normal position of anteversion: 1, Retroversion; 2, retroflexion (moderate); 3, retroflexion (marked) and prolapse.

the organ will be more or less permanently shifted out of position if the normal supports are persistently weakened by long-continued pressure upon or actual tearing of them. Of this group of causes may be mentioned:

(1) *Structural Conditions.*—This great group comprises those architectural faults in the skeleton that sooner or later lead to a shifting of the contained organs in an effort on the part of the body to maintain equilibrium and carry on function. These anatomic defects are often comprised under the term of "enteroptotic female."

(2) *Pregnancy.*—Here the organ increases in size and the ligaments are stretched; but the process is so gradual that no displacement occurs unless the outlet is torn at delivery (lacerated perineum); or the

organ fails to resume its normal size after the confinement (subinvolution); or where some infection leads to more or less thickening and rigid inelasticity of the ligaments, perhaps ending in *adhesions* that fix the organ in an abnormal position. Repeated pregnancies bring about the same results, and incidentally weaken the abdominal wall, allowing it to become flabby and atonic with subsequent relaxation or displacement of some or all of the contained viscera. Severe labors or those attended by complications at the delivery, or later, are manifestly prime causative elements. Patients who remain abed too short or too long a period after confinement often thus induce a malposition that inevitably gets worse unless recognized and corrected.

(3) *Infection of the Genito-urinary Tract.*—This acts by inducing inflammatory changes in the uterus or the adnexa leading to loss of tone of the normal supports, sagging of the heavy uterus, exudates, and perhaps adhesions. Such cases generally show some lateral displacement as well as retrodisplacement; any fixation is always an indication of an old process and usually is denotive of inflammatory or germ reaction.

(4) *Pressure.*—This may be due to sagging of the abdominal contents in general (enteroptosis) or be more or less localized, as from tumors, ascites, and the like, or it may arise from straining, as from constipation, weight-bearing, lifting, riding, posture, coughing, vomiting, and a variety of similar factors tending toward oft-repeated contractions of the abdominal muscles. Tight lacing, belts, and various fashions of dress fall in this group.

(5) *Weakness.*—Illness or other depleting causes may rob the organ of normal supports and thus lead to displacement. This group comprises also those cases occurring in the feeble, poorly nourished, and the aged, and in these the flabby abdominal wall is usually an index of a more or less general visceroptosis.

(6) *Injuries.*—These are likely to play a part only when the violence is capable of inducing a decided change of intra-abdominal pressure, notably when the impact has been in the nature of compression received on the front of the mid-abdomen. For this reason the most causative factors are falls against, or blows from, rather broad projecting surfaces; squeezing accidents, as between moving vehicles or objects; or violent twists or wrenchings with the pelvix fixed. All of these are associated with rather severe grades of trauma and other evidences of intra-abdominal injury often coexist. Such an *acute displacement* generally restores itself to normal unless the individual

is predisposed to the malposition by previously overstretched, boggy, or sagging parts.

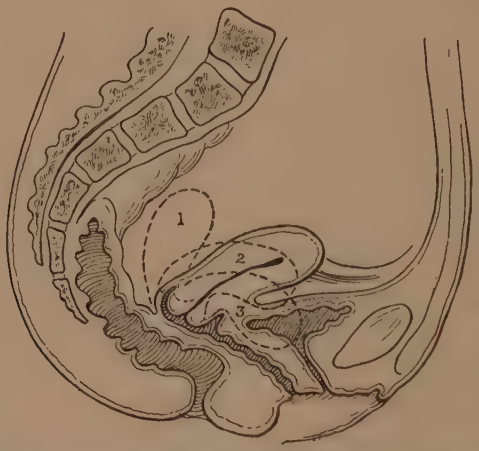


Fig. 517.—Uterine displacement, black line indicating the normal position of anteversion: 1, Retroversion; 2, anteflexion (moderate); 3, anteflexion (marked).

Personally, I have never seen a case of displacement of a previously normal pelvic organ from any form of violence, and certainly the condition must occur at once if at all.

Fig. 518.—Degrees of prolapse of uterus.

Indirect violence, such as blows or falls on the lateral or posterior abdominal walls, or jars transmitted from more or less distant parts, must necessarily be even more remotely regarded as causative agents.

Forward Displacement.—In this form the normal position of anteversion (65 to 85 degrees) is accentuated; and if the junction of the body and cervix is kinked or angulated, the condition is said to be one of *anteflexion*. This is a much rarer form of displacement, and obviously is much more likely to be a personal equation of congenital origin.

Causes.—Accentuation of the normal forward tilting is said to occur congenitally in 30 per cent. of cases. The *acquired* group of causes is similar to the preceding and depends practically on the same basic factors, namely, slowly increasing pressure from above that gradually crowds or forces the organ to assume an abnormal location (Fig. 517).

Downward Displacement or Prolapse.—This is always associated with backward displacement and is due to the same factors (Fig. 518).

Degrees.—First: When the tip of the cervix is below the vault of the vagina.

Second: When the tip of the cervix is at the vaginal outlet.

Third: When the cervix escapes from the vaginal outlet.

Nearly all of these cases show some cystocele and rectocele as well, and they are all characterized by slow development up to a certain point, and then suddenly they may become much aggravated as the last remaining supporting elements give way.

Practically all the cases occur in multiparæ with torn or relaxed outlets, or in the obese or the aged. A considerable number, however, occur in maiden ladies at or after the menopause, when atonicity is quite marked.

Kidney Displacement

At one time a kidney that could be palpated was regarded as being abnormal, but now we know that normally each kidney has a range of motion varying between 1 and 2 inches. This knowledge has made the operation of kidney fixation very much less frequent.

Werelius[1] says that Mesue in 1568 first mentioned this lesion in his work published in Venice; and in 1682 Riolan described it as a symptom-producing condition.

Anatomy.—Each organ weighs about 4½ ounces and is about 4 to 5 inches long, 2 to 3 inches broad, and 1½ inch thick. They are held in position in the hollow of the lumbar region mainly by the fat, areolar tissue, and retrorenal fascia surrounding their capsule, and to some extent by the vessels passing to and from them. The lower

[1] *Jour. Amer. Med. Assoc.*, March 1, 1913.

border of the right kidney is an inch or two below that of the left kidney because of the superimposed liver, and also because the right kidney niche is broader, shallower, and more open below than that on the left side (Volkow and Delitzin). Ordinarily the lower pole is on the level of the third lumbar vertebra reaching upward to the last dorsal vertebra (Fig. 519). These anatomic factors tend to develop kidney motility more frequently on the right than on the left side in the proportion of 13 to 1 (Piersol).

Types and Terms.—Movable kidney is one in which the organ can be freely felt to move during respiration, especially in inspiration.

Floating kidney is one that sags enough to feel the entire organ.

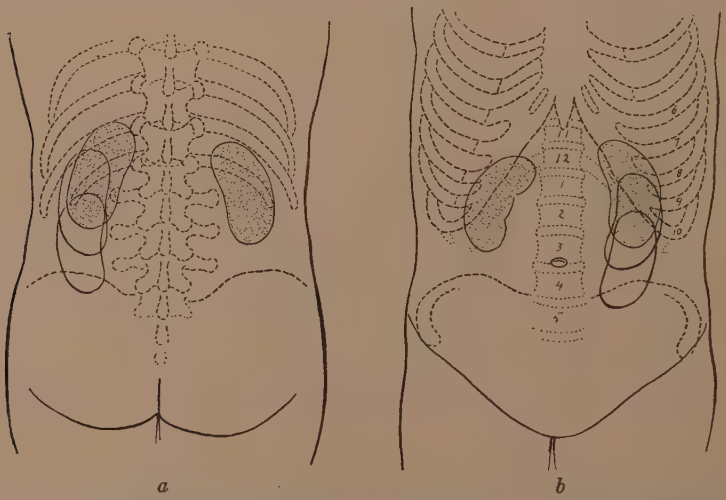


Fig. 519.—Normal and abnormal positions of the kidney: *a*, Posterior relationship; *b*, anterior relationship.

Wandering kidney is one that can be pushed freely about in all directions.

These foregoing limits of motion are variously spoken of as first, second, and third degrees respectively.

Causes.—Congenital motility is often present, especially in women, and some authorities assert that from 60 to 90 per cent. of women have more or less sagging.

Kister states that abnormal motility occurs once in 207 men, and in women once in 22. Other statistics state that it is palpable on the right side in 60 per cent. of cases, and in about 8 per cent. on the left side in men, and 30 per cent. in women.

The right kidney is involved, according to various authors, from twelve to eighteen times oftener than the left kidney. Both kidneys

are coincidentally affected in from 5 to 10 per cent. of cases, but the excursion on the right side is usually greater than that on the left. Associated enteroptosis and diseased conditions of the gall-bladder and appendix are often present. Most cases occur between the ages of twenty-five and fifty.

Structural formation plays a great part, and the long bodied and the lean are most prone because the hollow in which the kidney rests is less concave and also because the needed fatty support is scanty. These anatomic considerations have led to the formula of the so-called "kidney index" of Becher and Lennhoff to mathematically determine that a person of a certain structure is prone to displacement. This "index" is obtained by measuring the distance between the symphysis pubis and the ensiform appendix, and this is divided by the smallest circumference of the abdomen. The product thus obtained is multiplied by 100, and this gives the abdominal index. If this figure is over 75, there is a movable kidney tendency; if not, then, anatomically at least, there is no such predisposition.

The intact abdominal wall and pelvic floor are powerful dynamic and static elements in preserving the normal position of the kidney; hence *child bearing* is one of the main factors in its causation. *Tight lacing* is also an element, as is any form of *pressure* or dragging that tends in time to stretch or loosen normal supports of the organ.

Spinal curvature, congenital or acquired, may also induce relaxation.

Trauma is an infrequent cause, the type of accident producing it being generally a sharp impact in the lumbar region, as from a fall or blow. Jamming, jarring, and squeezing accidents sometimes act in the same way, assuming that the violence has been great enough to reach the lumbar region in an undissipated manner.

Symptoms.—The majority of cases gives no symptoms until attention is called to the condition, but thereafter in suggestible patients a host of subjective symptoms may be complained of, many of them of the neurasthenic variety. This combination of subjective "nervous" symptoms and movable kidney is very typical. Apparently the extent or degree of motility is not the measure of the severity of the symptoms, although "wandering" forms are most likely to give the maximum of discomfort. Symptoms referable to the motility itself are backache, dragging or tugging sensations in the loin or upper abdomen; indigestion, with or without vomiting, constipation, and jaundice; radiating pain transmitted along the iliolinguinal and iliohypogastric nerves to the groin or external genitals; and occasionally urinary irregularities.

"Dietl's crisis" is a paroxysmal attack of severe abdominal pain associated with vomiting and tympanites, followed by the passage of large quantities of urine occasionally containing blood. Such a seizure generally occurs in ancient cases and is sometimes induced by severe exertion, twists, or wrenches that produce a kinking of the ureter, leading to temporary hydronephrosis and increase in size of the tender organ. It is usually right sided and always unilateral.

An *acute displacement*, such as an injury may induce, is associated with tenderness in the costovertebral angle, some abdominal distention, tenderness, and rectus rigidity, and the urine for a short time generally contains blood. Ecchymosis and local evidences of injury in the lumbar area may not appear for several days; but such late signs are often corroborative of an acute origin or an exacerbation of a chronic condition.

Treatment.—Relief is usually obtained by wearing a suitable "kidney belt" or "kidney corset," either of which is applied while the patient lies flat on the back with the lower part of the body much elevated so that the abdominal contents may gravitate upward. Measures directed to the general condition of the patient must not be forgotten, especially forced feeding and exercises to strengthen weak muscles and alter mechanical conditions that tend to cause persistent sagging. Nervous symptoms also need attention, and no case will be permanently benefited without controlling ptosis of the other organs so often coincidentally involved.

Operation, as stated, is not now regarded as so necessary because most cases are controlled by non-operative measures, and the majority of surgeons counsel palliative treatment unless careful attempts meet with failure.

Nephrorrhaphy and nephropexy are the terms used for the operation of "kidney fixation," and a variety of procedures have been devised to replace the organ and retain it in position by sutures introduced into the capsule alone, or into the capsule and kidney substance, thence fastening it to contiguous muscle, or muscle and fascia.

In selected cases, operative treatment is exceedingly effective and is relatively free from danger.

Gastro-intestinal Displacement

The stomach, colon, cecum, liver, and other portions of the digestive tract are sometimes found in abnormal positions (Fig. 520). We now know that such conditions almost uniformly depend upon congenital malformations or are acquired as the outcome of long-standing

processes arising from posture, pressure, or infection. Abnormal relaxation of the abdominal muscles, as in "Glénard's disease," is a frequent finding in these cases. *Trauma* plays little or no part in their production.

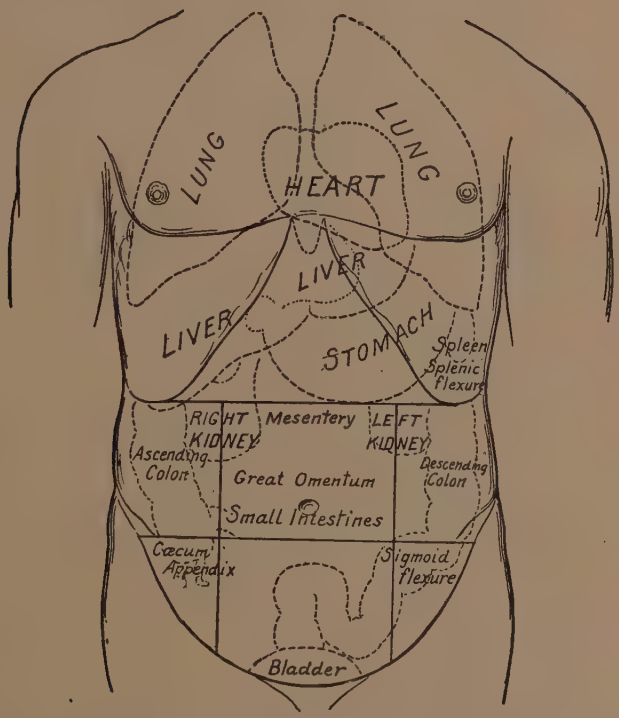


Fig. 520.—Relation of viscera to parietes.

Speaking generally, any displacement of a viscus is essentially a hernia, and is dependent more upon inherent structural causes than upon external or incidental factors. Even in the presence of very severe injuries I have never seen a case associated with visceral displacement, nor have I ever operated on a patient with a displacement due to external violence.

CHAPTER XX

THE TRAUMATIC NEUROSES

THESE consist of *neurasthenia* and *hysteria*, and because they are so often associated the name hysteroneurasthenia has often been applied to them. My experience has been that neurasthenia may exist alone quite frequently, but hysteria is quite regularly associated with neurasthenia.

The diagnosis of neurasthenia is certainly less common now than formerly, and the traumatic forms are very rarely encountered except in litigated cases where the subjective manifestations are many and varied, but the objective verifications few and limited.

In the Neurological Institute of this city in the past 3 years a diagnosis of neurasthenia "group" has been made 149 times in 5967 hospital patients treated for all forms of nervous disease. Many cases formerly diagnosed as neurasthenia are now known to be manifestations of arteriosclerosis, unsuspected lues, goiter, gastro-intestinal, pelvic, rectal, internal gland, prostatic, and other diseases.

It is certainly true that the neuroses are excessively rare in ordinary hospital and civil practice, and this has led to the belief that many of the cases are due to autosuggestion or heterosuggestion from physicians, lawyers, relatives, and others. Some of this is probably not purposeful, but is the outgrowth of injudicious remarks made in the presence of the patient or later repeated to the latter by others. A certain class of physicians are fond of dilating on the subject of "possible internal injuries," "brain damage," and "spinal trouble" in the presence of an injury respectively to the abdomen, head, or back. The statement "you may be a cripple for life" sufficiently often repeated is certainly not likely to increase optimism or act as a stimulus toward recovery. If this is true where there is no special object to be attained by prolonging disability, it is increasingly true when there is gain in view.

In years gone by railroad accidents were supposed to inflict special forms of neural injury, and to these the name "spinal concussion," "railroad spine," and "railroad brain" were given. Erichsen, about 1874, thus christened this ailment, and since then it has been occasionally heard of, but only in connection with claims for damages. Strangely

enough, of the 53 reported cases in Erichsen's two books, less than one-third were hurt in railroad accidents, and, as stated by Bailey, in the total number of cases reported there is not one in which a diagnosis of "spinal concussion" due to "molecular changes" would stand present-day analysis. The only case of the group that was subjected to autopsy was clearly a case of locomotor ataxia, and with our present knowledge it certainly would not be denominated either as "railroad spine" or "spinal concussion." Several of the cases cited by Erichsen were very severe traumas of the spine that today would be recognized as fractures of the laminæ or other vertebral processes; others less severe were intraspinal hemorrhages.

Since Erichsen's time a large number of books and articles have been written abroad on the subject, some of the more important being by Page, Westphal, Charcot, Strümpell, Oppenheim, Janet, Freud, and others; and in this country by Dana, Hamilton, Walton, Outten, Angell, Putnam, Dercum, Bailey, and many others. Oppenheim is responsible for the name "traumatic neurosis."

The condition has been still further clarified by insurance statistics, notably those from Germany and Great Britain, and it is from reliable statistical official sources of this sort that the best knowledge is obtainable.

A great many extreme views have been entertained and expressed respecting these subjective nervous disturbances, one group of observers maintaining that the symptoms are assumed and purposeful, and, in reality, non-existant; another group maintains their reality, severity, and permanency.

The personal equation appears largely to govern these diverse views, and many of the opinions expressed are based on a few cases and a limited experience with injured patients; others are too strictly racial or sexual. For this reason there is still a wide diversity of opinion, but uniformity is now more marked than at any other previous time, not only as to diagnosis but also as to treatment and prognosis.

The writer has had a rather varied experience in the examination of persons claiming injuries in railroad and other accidents, and during that same period has had an active traumatic service in hospital, dispensary, and private practice. The material thus provided, together with a fair knowledge of the existing literature on the subject, causes the writer to state the following as his interpretation of the present status of these neuroses:

(1) They do occur, but are in no essential respects different from the same diseases due to numerous other causes.

(2) They have a definite and demonstrable symptomatology and many of the subjective symptoms can be made objective.

(3) In the vast majority of cases they are claimant-neuroses and are rarely seen unless some claim is pending.

(4) They are rare in hospital practice or under similar environment.

(5) The element of suggestion, self or otherwise, is a powerful stimulus.

(6) The less serious the injury, the greater the possibility of developing the neuroses.

(7) The manifestations, duration, and outcome bear a close relationship to the negotiations for settlement.

(8) Most cases recover after the mental source of worry or expectancy is relieved.

(9) Neurasthenia with hysteria is commoner than hysteria with neurasthenia.

(10) Recurrence in hysteria is more likely than in neurasthenia, but both may return.

(11) Late development of neuroses does not often occur if settlement has previously been made.

(12) In the vast majority of cases some motive is present, such as money, vacation, revenge, pride, spite, pique.

As stated, in my experience it is rare to find hysteria alone or neurasthenia alone, and for that reason I have come to use the term *traumasthenia* to denote that combined grouping of nervous symptoms so frequently alleged after an accident. At the present time no special form of neurosis is claimed to be typical of certain occupations, methods of construction, railway transit, or development; and, practically speaking, a neurosis is just as likely to occur from falling on the sidewalk as from a rear-end collision, from the fright of a fire, or a wound received in battle.

In about three-fourths of the legal papers, allegations of "nervous shock" are made and over one-half claim "nervousness" of some sort; thus in litigated cases the condition is wide-spread and examining physicians in such instances expect these assertions almost as regularly as complaints of pain.

There is no good reason for accepting an injured patient's statement that "nervousness" is present, and then translating such an assertion into a technical diagnosis of "traumatic neurosis" unless there are definite objective symptoms for verification. In no other condition is the assertion of the patient so unreservedly accepted and acted

upon by the attending physician, and thus by added suggestion the mental side of the ailment is kept alive by the very person who should do most to banish it by refraining from putting too much value on mere complaints.

NEURASTHENIA

Literally, this means "weak nerves"; the terms "nervous prostration" and "nervous breakdown" are synonomus, and since Beard's first description of it, it has also been known as the "American disease." My personal belief is that in a decade "traumatic neurasthenia" will pass out of medical literature after the manner of "spinal concussion."

Definition.—A functional disease of the nervous system due to a large number of causes, characterized by mental and physical incapacity for sustained effort, and presenting numerous subjective and some objective symptoms particularly connected with the cardiovascular and muscular systems.

Causes.—As stated, these are very numerous, and of them may be mentioned any of the factors of modern stress and strain that go to make up the strenuous life. Overwork, worry, grief, insomnia, alcoholism, exhaustion, moral, mental, social, and physical excesses, or, indeed, any set of causes that make for physical or nervous depletion.

An unstable nervous equilibrium, hereditary or acquired, is usually a prerequisite, and it has been truly said that the neurasthenic is born and not made, so strong is this element of predisposition.

A considerable number are due to disturbances of the physiology of the abdominal, sexual, thoracic, and cranial organs, constituting the so-called "reflex" sources. Visceral ptoses, notably nephroptosis and enteroptosis, cause or are associated with a certain proportion of cases. Another factor is acute or long-continued disease, or sudden changes incident to occupation, environment, or station in life. Disturbance of the internal glandular mechanism, notably of the thyroid, is also an element.

Men are more commonly affected than women; it is rare before the twentieth year and is distinctly an adult disease. Racially it is common among persons of Jewish ancestry, notably among the poorer and richer classes. The middle class group of all races are less prone than the rich or the poor. The more rational the work and play of the person, the less liable the disease.

Traumatic sources have their basis in psychic and physical shocks, and it is to be recalled that actual physical contact is not always necessary to its production in those predisposed. It is claimed by some that the psychic insult from the sights, sounds, and impressions of

an accident are as potent producing causes as the actual physical hurts. This is not in accord with my experience, which is that the occurrence from psychic impressions alone is far less frequent than in hysteria, and the neurasthenia alleged to follow slight traumas must be looked upon with great suspicion and sharply differentiated from hypochondriasis and malingering.

No physical injury to any part of the body is too great nor yet none too slight to induce symptoms.

The element of suggestion is very important, and this takes the form of environment and treatment, as well as the sayings and doings of friends and others. There is no special form of injury more capable than another of inducing traumatic neurasthenia, and thus head, spinal, and pelvic injuries are no more competent producing causes than injuries elsewhere inflicted.

Symptoms.—These are most readily grouped according to their regional distribution, and may be referred to as *cerebrospinal*, *motor*, and *visceral*, all of which are subjective mainly, but also objective. It is rare to have one group sharply defined and the usual combination is the cerebrospinal.

The *time of onset* varies, but it is usually prompt and rarely delayed more than a few weeks.

Cerebrospinal Form.—Pains and aches in various regions are largely complained of, and most of these cases start with the suggestion implanted by an injury to the head or back.

"Cerebral neurasthenia" and "spinal neurasthenia" are sometimes used as denominative terms.

Headache is one of the common symptoms, and this is usually referred to the region of the forehead or base of the skull, and is described as sharp and occasional or dull and constant. Usually excitement or sustained effort increases it.

Backache, sometimes called "spinal tenderness," is the second most frequent symptom, and because of it the patient often infers "spinal trouble" and correspondingly worries respecting it.

This locational manifestation was the chief feature of the cases formerly diagnosed as "spinal irritation" and "railway spine."

The pain is ordinarily located at one or all of three locations, viz.: Over the back of the neck about on a level with the vertebra prominens; about the midscapular level; and near the dorsolumbar junction. The pain is said to be accentuated by motion and pressure and the patient is able to sharply delimit its site by pressure of his own finger. Usually the pain is said to be superficial and over the spinous processes

exactly in the midline, and less often just external thereto. If the pain occupies a wide area, it is almost invariably said to be located in the lumbar region. Pressure of the examiner's finger causes the patient to wince or exclaim, and occasionally a muscular contraction can be seen or felt. If these painful spots are marked by pencil or pen, the patient can accurately relocate them in genuine cases; this may be termed the "relocation test" and is applicable to any area of alleged tenderness. Increase or change of pulse-rate on pressure over these or other painful areas—the so-called "Mannkopff-Rumpf test"—has not proved of much value to me.

The attitude of a patient with a tender back is often quite suggestive, as a posture and gait are assumed to relieve pressure and strain.

Occasionally the pain is said to be of a darting type, radiating toward the intercostal spaces or up and down the back or into the limbs.

Aching in the limbs is sometimes asserted, especially along the calf, and this gets worse from walking and standing, and hence the patient complains of weakness and incapacity for sustained effort and pleads ready fatigability. The muscles thus get flabby and soft from disuse, but actual atrophy practically never occurs. Joint pain is occasional also, and rheumatism and other articular ailments must be differentiated.

Memory deficiency may be complained of and the patient asserts that recent events especially are not sharply impressed; less often memory for distant happenings is blurred. This memory trouble is also an evidence of tire or weakness and an added sign of the prevailing instability or incapacity for effort, and it by no means denotes any true mental failure or disease. All the details of the accident, however, and the minutest circumstance intervening can usually be narrated with such effect that the patience of the listener will be taxed. Verbal display of this sort is common, but it is much more frequent in non-traumatic forms.

Concentration loss is allied to the preceding and is often the actual deficiency that leads to the suspicion that memory is hampered. Lack of attention and inability to "put the mind on it" are the main elements.

Introspection and brooding are consequences of the patient's false beliefs that some serious and incurable ill has befallen him. He has so often rehearsed his own symptoms to himself and others that he comes to believe in their reality, and a fixed idea gets possession of him to such an extent that he thinks of little else. Lacking judgment or proper

reasoning perspective, he gives inordinate prominence to trivial events, remarks, and written statements, and thus builds quite a structure that may have a slim foundation in fact.

Tears and various *phobias* are occasionally present, but less often than in other forms of the disease.

The fear of riding in railway cars is known as *siderodromophobia*, and this sometimes develops in those hurt on transportation lines.

Changes of temper and *character* are quite common, and the patient is easily upset by trifling circumstances and is likely to be cross and irritable. Emotional upsets are not as common as in hysteria, but tearfulness is often prominent.

Hesitancy and lack of decision and precision may also occur as indicative of the general lack of stability. Obsessions and imperative impulses and similar conditions are exceedingly rare. Threats of self-destruction are rather common in other forms, but very rare in this type.

Insomnia is often claimed, and yet the general appearance is frequently so good that this symptom is probably exaggerated in the patient's mind. Dreams are not uncommon and these may rehearse the circumstances of the accident.

Special senses also sometimes manifest similar evidences of fatigue.

Vision may thus be said to be diminished, this being a combination of lack of concentration and weakness of the muscles of accommodation. The patient may say that continued reading is impossible and in some cases the aid of glasses will be required. A host of visual subjective symptoms may be alleged, such as bright lights, floating specks, and other phenomena. Sometimes the pupil is quite large, but it is never irresponsive.

Hearing may be said to be deficient and auditory sensations of variable kinds may be mentioned, notably roaring and buzzing sounds, perhaps associated with dizziness or vertigo. Usually auditory symptoms are unilateral.

Smell and *taste* may uncommonly also be subjectively upset, but far less often than in hysteria.

Motor Form.—Here the injury is often to a muscled part, as an arm or leg.

Weakness of muscle is a main feature, and the part is toneless, flabby, and soft, but true atrophy does not occur, any shrinkage being due to disuse. Sustained effort of the part involved is lessened, and this may at times be measured by an instrument known as the *dynamometer*, a form of gripping machine designed to test the grip. This is so much under the control of the patient that it is practically a sub-

jective test and of no more positive value than the response obtained by asking the patient to squeeze the examiner's hands. An improvised test of a similar form has occasionally been of some use, and all that is needed is an ordinary stationer's rubber band, the patient being requested to pull this against the resistance of his own hands or those of the examiner.

Early fatigue may prevent walking, standing, and working, and these people are given to sitting or lying around, thus increasing their muscular flabbiness.

Tremor is quite common and generally is increased by exertion, excitement, or emotion. It is most typically seen in the hands and fingers, and when not fully visible can often be made palpable by asking the patient to put the tips of four extended fingers against the examiner's palm, when a vibration will be readily apparent. The type of tremor is usually fine, ordinarily inconstant and irregular, and not of wide excursion. It may be seen in the tongue also, and is very often seen in the eyelids, especially when the patient is asked to stand erect with the eyes shut. The various muscles about the face less often are tremorous or twitch, notably those about the forehead, corners of the mouth, and chin. The muscles of the trunk, back, and limbs are occasionally the seat of tremors, and these become more prominent during manipulation of the parts, the movement not infrequently then becoming very marked and almost convulsive or spasmodic.

Reflexes are usually exaggerated, notably those of the knee, elbow, and wrist. A rather characteristic feature is the variability of the tendon-jerks, as on one occasion they may be quite lively, and at another relatively normal, and they may differ on opposite sides. The extent of reflex response is often a personal equation, and may have wide variations and still be within the normal for that particular individual; but sluggish or absent reflexes, especially if bilateral and constant, should put the examiner on guard as to the possibility of some organic ailment. The superficial reflexes are less constantly affected than the deep, but when involved show the same degrees of varying exaggeration. After repeated tests of the reflexes they may act less promptly than at first, thus indicating fatigue.

Visceral Forms.—These are usually associated with that class of accident in which the patient is impressed with the idea of "internal injury."

The heart and blood-vessels frequently manifest characteristic evidences of unstable innervation, notably as to cardiac rhythm and vasomotor control.

Heart action is generally rapid, and palpitation is not only complained of but is ordinarily demonstrable. Various subjective complaints are made, such as attacks of anginal pain, precordial distress, and throbbing and pulsating sensations, notably in the neck. Shortness of breath and weakness on exertion may also be asserted.

Vasomotor tonal disturbance is indicated by alternate pallor and blushing, or flushing of the skin, notably during exertion, emotion, or excitement. It is most marked in the face and to a lesser degree on the neck and upper chest.

Cold extremities are often present, and sweating and dampness of the palms and soles are not uncommon. Ordinarily, sweating can be induced by slight exertion, and it is common during excitement, being most marked on the forehead and under the arms.

Digestive organs are generally little involved, although the appetite is often said to be perverted or diminished; often this, like marked insomnia, is a patent exaggeration, as the loss of weight may be inconsiderable; subjectively, complaint may be made of nausea, flatulency, constipation, and other signs of gastro-intestinal atonicity.

Kidney action is generally normal, but the urinary output in a person taking no exercise and living under strained conditions will be necessarily altered. Arising at night to urinate is a frequent complaint and is probably an index of restlessness or perturbation. Occasionally an irritability of the bladder makes it necessary to frequently empty this viscus. Actual urinary changes are rare; very occasionally transient albuminuria and glycosuria may occur, probably entirely dietetic in origin. Indican is generally increased, but there is no basis for the belief once entertained that this ingredient in excess is typical of neurasthenics.

Sexual organs are frequently less active, and at one time this condition was dignified by the term "sexual neurasthenia." It is much more common in the non-traumatic forms and not a little of it is due to the suggestions of "lost manhood" conveyed by certain forms of literature. Apparently the prevailing neurasthenic element of "sexual instability" and incapacity is manifest here as elsewhere, and men are more affected than women; seemingly erectile is more affected than the secretory or emission capability. Manifestly most of these complaints are entirely subjective, and unless the external parts are flabby and toneless, and the other neurasthenic symptoms are demonstrable, it is inadvisable to regard these claims too strongly. Actual impotency from non-organic sources is so excessively rare that few authentic cases are recorded. Subjective complaints of pain and altered sensations

referable to the sexual organs are often limited only by the patient's imagination and vocabulary. Women occasionally refer to pelvic pain and feelings of aversion regarding the sexual act, but objective manifestations are notably rare.

Emissions in either sex are very much rarer than in other forms of the disease. Menstruation may become deficient or otherwise altered in rare instances.

The symptoms are so numerous and diverse that it would be manifestly impossible to observe all of them in a given case, but a typical instance of the traumatic form usually develops and presents itself in some such way as this: A rather "highly strung" but perhaps otherwise perfectly well man or woman is in a collision between vehicles or is hurt in a falling elevator or on a "defective" pavement or stairway. The actual physical injury would be diagnosed perhaps as "shock, general contusions and abrasions, and lacerated scalp." At the time of the occurrence there was some dizziness, nausea, and perhaps vomiting, but actual prolonged unconsciousness did not occur and the circumstances of the accident were perfectly apparent and readily remembered. After treatment by the ambulance surgeon or a short stay at the hospital, the patient returns home alone or by the aid of friends, frequently being able to walk unaided. A physician is summoned and the patient is put to bed, the hospital dressings usually being unremoved. Up to this point there is nothing about the case to differentiate it from another with identical injuries received in some manner that makes the collection of damages unlikely. In the case under discussion, however, visits from lawyers, claim adjusters, advising friends, and others soon leads the patient to proclaim various subjective symptoms of "nervousness" which are dignified by the doctor or others into some high-sounding title like "traumatic neurasthenia."

Usually within a few days the patient is honestly, or otherwise, impressed by the fact that the hurts are serious, and "nervous prostration" is in process of development. A doctor representing the prospective defendant now appears, and his examination and questions may suggest further symptoms and perhaps disclose some objective signs which the patient and attending doctor had not discovered, all of which will be ascribed to the accident.

The examining physician will be told of severe headaches and pain along the spine, of insomnia and bad dreasms, of irritability, weakness and dizziness, and of poor appetite. His examination discloses a person of fair physique with some insignificant scars and fading con-

tusion discolorations. The pulse is at first rapid, and then perhaps returns to normal; the temperature is not elevated. There is some tremor of the fingers and tongue and closed eyelids. Some places along the midspine are apparently tender to slight touch and react thus to the "relocation test," yet the patient lies on these supposedly tender spots and moves readily without comment. The knee-jerks are lively and the muscular power somewhat diminished. There are no central or superficial organic nervous changes.

Left alone, such a patient would be at work in a few weeks at the most.

Perhaps at this stage, however, the attending doctor, alarmed by his patient's many complaints or the importunities of the family, calls in a surgeon or neurologist, and again the patient gets a new set of suggestions. In this manner a fortnight or a month passes, and meanwhile no financial adjustment has been made, and legal papers are served. The patient signs and swears to these after reading or hearing his injuries described in awful terms, and then for the first time he may learn that his hurts are ". . . of such a nature as to render him sick, sore, lame and disabled in mind and body, and he is and will be permanently incapacitated and forever unable to resume his regular duties. . . ."

Naturally enough all these preliminaries are outrageously bad for an honest claimant and ideally good for a fakir.

Admittedly a large number of cases are deliberately manufactured by interested parties who find many of the injured readily susceptible to suggestion and predisposed to neurotic manifestations. If the case goes on to trial, a year or two may elapse before the actual "day in court" arrives, and in that interval the patient may have done little or no work, and thus practically the whole time is taken up by introspection and brooding. All sorts of doctors, drugs, and "treatments" may have been more or less diligently employed, but meanwhile the patient has not been isolated and complete change of enviromnent cannot occur until litigation is ended. Many rehearsals are necessary before the jury appearance, and perhaps also more examinations by experts for both sides, and then the patient goes upon the witness stand and tells as much as is allowed of the preceding and intervening circumstances. By this time the average person is probably much impressed with the gravity of the ailments and may in court exhibit many indications corroborative of the condition, especially if this form of excitement and exhibition brings on violent trembling, agitation, emotion, and perhaps fits or fainting. If the verdict meets anticipations, a great source of worry is removed and the patient promptly

transfers his attentions from himself to something else and begins to get well. If, however, litigation is prolonged by appeals, the neurosis often continues also until this source of suggestion is removed.

Most of the symptoms begin within a few days, but in some there is an interval of a few weeks during which time the patient may have been at work and apparently well. Some of these cases of late onset bear a close relationship to the advent of not wholly disinterested medical and legal advisers.

Obviously a disease of this sort offers splendid opportunities for the malingerer and fakir, and many cases are wholly of this spurious type. There can be no question that many honestly disposed persons are made neurasthenics by the circumstances surrounding our present-day methods of dealing with compensation for injuries; however, that compensation laws do not cure the evil is well shown by recent statistics from England and Germany, which indicate that malingering is largely on the increase, inasmuch as there is a predetermined legal payment during a disability that is asserted or apparent.

Necessary to a Diagnosis.—It is not enough, as already stated, to take the patient's say-so in regard to "nervousness," but an effort should be made to render some of the subjective signs objective. It is not to be forgotten that many persons may have nervous symptoms of a so-called neurasthenic type (notably the cardiovascular group and tremors) and yet not have the symptom-complex of the condition or enough symptoms grouped to complete the diagnosis.

There is no one pathognomonic sign but a typical case of a few weeks' duration should show several of the following more or less prominent objective signs:

(1) *General appearance* is often suggestive, as might be expected of one complaining so constantly and variedly.

(2) The *expression* is care-worn, anxious, and not alert, especially if headache and insomnia are featured.

(3) *Loss of weight* may be apparent.

(4) *Alternate pallor* and *blushing* may appear.

(4) *Tremors* of the eyelids, mouth, chin, tongue, and fingers may exist; jerking of the arms and hands may occur.

(6) *Pulse* is variable, and at first is likely to be rapid, as might be expected on the arrival of a stranger. Later it slows down, but again becomes rapid; this change of rate, especially on exertion, is quite typical.

(7) *Throbbing* of the carotid, brachial, and femoral arteries may be visible and palpable. When the pulse is first taken at the wrist the

jerking of the extremity may be quite marked and rhythmic, but it can be stopped by diverting the attention.

(8) *Cold extremities* and *sweating* are quite common.

(9) *Reflexes* are lively, more so at first than later, especially at the knee; a spurious ankle-clonus is sometimes present. The reflexes may be asymmetric.

(10) *Tender areas* along the spine are demonstrated as real by the "relocation test" and the general attitude and actions of the patient.

(11) *Muscular power* is lessened as denoted by the atonicity of the calf, thigh, arm, and forearm groups; some of this depends upon how inactive the patient has been. Grip-power is determined by asking the patient to squeeze and push to and from the examiner's hands; also by pulling taut during the "rubber band test," or by the dynamometer. The power of the legs can be tested by having them moved against resistance. If the patient is honestly endeavoring, for example, to raise the *right thigh* off the bed against the examiner's resistance, then the muscles on the front of the *left* thigh will be seen and felt to contract.

Of the foregoing, the chief importance in the traumatic form would be the grouped manifestations under (1) General appearance, (5) Tremors, (6) Pulse, (9) Reflexes, (11) Muscular power. Of these eleven objective signs, at least four should exist before a diagnosis is made or accepted.

Differential Diagnosis.—In an ailment of this sort with such wealth of subjective and poverty of objective symptoms it is advisable to consider what is necessary to make a diagnosis of a true case with a view to excluding—

Hysteria.	Lumbago-rheumatism.
Malingering.	Goiter.
Epilepsy.	Visceroptosis.
Phrenasthenia.	Arteriosclerosis.
Cerebral / Spinal } disease.	Paresis.
	Multiple sclerosis.

HYSTERIA

The derivation of the word means "womb," and for a long time the disease was supposed to be associated with and limited to female disorders. This ailment has existed at least since the days of Hippocrates (125 B. C.) and has been the subject of much controversy. Charcot probably did most to clarify the situation respecting it, and his views are even in this day substantially regarded as correct. He taught that

the traumatic form was, in effect, a manifestation of self-hypnosis due to the psychic and physical shock, and that the symptoms were in part determined by the suggestion made on the patient's mind by the nature of the accident and the part of the body injured.

Definition.—A functional disease of the central nervous system due to a large number of causes, and characterized by mental, motor, sensory, and visceral symptoms of such wide scope as to embrace at least some of the manifestations of nearly every other derangement.

Causes.—These are legion, but the essential element is that the person should manifest the "hysteric temperament" which is ordinarily hereditary. This implies that the so-called *stigmata* or *signs* of the disease pre-exist, and that the outbreak is due to a wide variety of exciting causes capable of inducing manifestations known as *accidents of hysteria*. In other words, the *stigmata* always have and will continue to exist, but the *accidents* will disappear and can be induced by certain mental and physical stimuli.

No true hysteria can occur unless the person was previously hysteric in type, and to that extent susceptible and liable to its development.

Psychic sources of origin are more potent than physical, and the latter without the former are incapable of inducing it. Susceptibility to suggestion is very prominent, and impressionability and emotionalism are quite characteristic.

Women are oftener affected than men, and it is commonest at the age of puberty and most likely to appear at menstrual periods. All grades of society are involved, but a larger share are provided by the poor and overworked, or the indolent and rich. The Jewish race is especially susceptible, and the Latins more prone than the Teutons.

Any sort of mental or emotional shock may be the inducing essential cause, particularly sudden grief, joy, anger, sorrow, fear, fright, anxiety, worry, distress, catastrophe. Likewise, abnormal stress and strain, or sexual impressions, and fears and hopes are factors. Religious excitement and the rigid advocacy of cults and sects are sometimes causative, and the active devotees of some of these are by many regarded as hysterics.

Traumatic sources of origin are, of course, very numerous, but the essential and necessary element is *fright* or *psychic shock*, and for this reason the sights and sounds of an accident may be provocative even in the absence of actual physical damage. In this respect, as in many others, it differs markedly from the allied neurosis, neurasthenia, in which some physical injury is usually a *sine qua non*.

There is no special section of the body when injured more likely than another to produce hysteria; nor is there any special sort of violence especially provocative, assuming that the elements of fright and psychic shock exist. However, the mental impression or suggestion derived from the manner of the accident and the place of the receipt of the violence often determine the hysteric symptoms; and, indeed, certain manifestations can be predicted from a given set of psychic causes and physical results, in a properly predisposed subject, by a process of psycho-analysis, a topic so prominently brought forward by Freud and his followers in an attempt to fathom symptoms of a more or less hysteric type. For example, a blow on the arm may create a strong mental impression and fear of paralysis, and by a process of self-hypnosis the patient believes the arm powerless, and it thus becomes more or less disabled and useless and to all intents and purposes practically paralyzed. The same psychic control of "mind over matter" may induce other forms of hysteria, and the analysis of the manifestations of many of them will show that the condition started from some mental suggestion, that is perhaps a repetition of a memory or occurrence rendered fresh and active in the patient's mind by the psychic shock or mental impression of the recent accident or occurrence.

Hysteria has been aptly termed "the great mimic," and this is true not only as to its production but also as to its capacity to feign or simulate almost every pathologic condition to which human flesh is heir. The element of severe violence is not necessary, and, in fact, many extreme cases arise without any external physical force whatever.

A fit of anger, the occurrence of sudden good or bad fortune, an escape from threatened disaster, or any sudden psychic trauma are just as inducing in a hysteric as a similar grade of physical trauma. That is one reason why hysteria so uncommonly occurs when the patient is unconscious or asleep, or otherwise in a stage of unpreparedness.

It is much less common than traumatic neurasthenia, and in my experience, as stated, the combination of neuroses is much more frequent than either separately.

Symptoms.—These are exceedingly numerous, and, as already indicated, there is practically no human disorder that fails to present some signs of hysteria, and in many instances the presence of stigmata and the grouping of symptoms are the real differentiating factors.

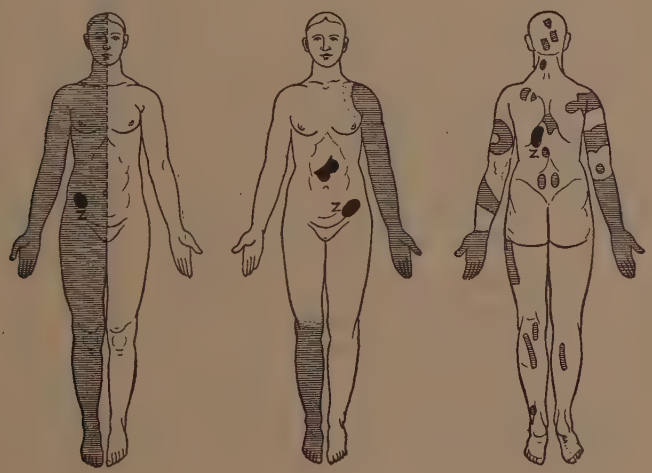
There are two main forms, *major* and *minor hysteria*, the former being unusual in this country, but rather frequent abroad.

As stated, the *stigmata* are permanent, innate and hereditary, and

may and ordinarily do exist unknown to the patient until some occurrence or examination brings them to notice.

These stigmata are pre-existent and in the main consist of:

(1) *Anesthesia Areas.*—Certain segmental, irregularly distributed surfaces of the body are insensitive to pain (analgesic) and touch (anesthetic) and occasionally to heat and cold (thermal anesthesia), and these are known as "hysteric zones" or "hysteric areas" or "hysteric spots." None of them bear any anatomic relationship to the underlying nerve-supply, and they are shifting, inconstant, and very variable in degree and extent. Pressure on some of these areas may induce or suspend hysteric manifestations, and they are hence known as "hysterogenetic zones."



a *b* *c*

Fig. 521.—Hysteric zones and anesthesia areas: *a*, Hemi-anesthesia and ovarian zone; *b*, "stocking and glove" anesthesia, ovarian and umbilical zones; *c*, irregularly distributed areas of anesthesia, dorsal or spinal zones.

The commonest distribution is along the lower abdomen, near the nipples, over certain portions of the back, and on irregularly and widely distributed spots on the extremities (Fig. 521). In women, "ovarian zones" and "mammary zones" and "vaginal zones" are frequent and denote areas of altered sensation in these respective regions. Insensitiveness of the conjunctivæ and pharynx are also common.

(2) *Hyperesthesia Areas.*—These are the reverse of the preceding, and consist of irregularly distributed areas unusually painful to touch and pressure. They are commonest along the spine.

(3) *Vasomotor Areas.*—Certain portions of the skin, notably the

back and abdomen, become pinkish or more or less mottled when irritated by pressure, and a red line with white edges can be produced by the finger-tip or other blunt object drawn along the surface; this is the so-called *tache cérébrale* and is supposed to indicate an anesthetic condition of the superficial blood-supply.

(4) *Visual Areas.*—Perception for light and color are altered, resulting in "contraction of the visual field" and "reversal of the color field" (Fig. 522).

(5) *Emotional States.*—The hysteric is generally of a highly strung type and of imaginative and vivid mentality, readily given to moods, whims, and alterations in behavior and action toward self and others.

The *accidents* or *incidents* are temporary, acquired, and variable, and are the outgrowth of exciting causes reacting upon a subject possessed of the preceding stigmata; the main manifestations are:

(1) *Paralyses.*—Usually one limb is involved (monoplegia); occasionally one lateral half of the body (hemiplegia); or two limbs (diplegia); or a lower extremity (paraplegia). The part paralyzed as to motion is generally also anesthetic.

(2) *Contractures.*—These are in the paralyzed areas, notably manifest in the hands, feet, and limbs.

(3) *Convulsions.*—Fits of various degrees may occur and are usually induced by emotional accessions.

(4) *Visceral Changes.*—Certain cerebral, abdominal, and genito-urinary manifestations are relatively frequent.

An individual discussion of symptoms can best be made by dividing the manifestations into *motor-sensory*, *psychic*, *special sense*, and *visceral* groupings.

It is to be understood that a given case may demonstrate but one set of the foregoing phenomena, or combine all of them.

The *time of onset* and *extent* of symptoms varies, but usually is quite prompt and complete, and may immediately follow the accident. Rarely is there an interval of more than a week, and the longer the delay, the greater the probability of added suggestion, especially that implanted by the medical treatment, or the remarks of visitors. I have known cases to develop from newspaper accounts of court proceedings, and in the clientele of a certain class of physicians and lawyers the occurrence is common enough to raise the suspicion that the disease is directly due to their hypnosis by constant suggestion in a susceptible and perhaps willing subject or "medium."

Motor-sensory Form.—This is perhaps the commonest, and is usually produced by some suggestion from an injured extremity, so that

the subject is impressed with the idea that the part can neither feel nor move.

Paralysis is most commonly limited to one limb (monoplegia) or a portion of it, notably a hand or leg. It may be a weakness or actual complete loss of motor power, so that the part is lax (flaccidity), or it may be somewhat rigid and tense (spasticity), notably when the muscles opposing the palsied group are in a state of contraction. Involvement of the lateral half of the body may also occur (hemiplegia), and this is commonly the left arm and leg, the face very rarely being affected. Two limbs (diplegia) or the lower extremity (paraplegia) are less usual types of involvement. The paralyzed part dangles limply and an affected arm or leg drops listlessly when raised. In walking, the gait is characteristic, in that the foot of the involved leg dangles along the toes as if the limb were hung on a springless hinge at the knee.

Spasm and *tremor* may occur in the involved muscle group, or independently; it is likely to be coarse and jerky and is usually increased by effort ("intention tremor").

Inco-ordination of the affected limbs is common, and an ataxia of some grade may exist. The gait is quite likely to be faulty and movements generally may be awkward and attitudinal, this being rather pathognomonic.

Astasia-abasia is inability to stand or walk, and is ordinarily an associate of the paraplegic form; the patient, however, may be able to slightly move the lower extremities when lying down. This usually is a temporary occurrence in the course of the disease and may appear suddenly in attacks; it is sometimes referred to as "cerebellar hysteria." I have seen but 4 traumatic cases of it.

Contractures may occur independently or in the paralyzed part, so that a rigid postural attitude is maintained. This is often so characteristic that a diagnosis is possible by inspection, and is most common in the extremities, but may involve any part of the body and become quite theatrical or acrobatic.

Sensory changes ordinarily are found in the paralyzed parts, but may occur independently.

Anesthesia is the commonest form, and the loss of sensation to pain (analgesia) is the usual manifestation, although the response to touch and thermal stimuli may be coincidently involved. Sensation may be wholly or partly lost (hypesthesia), and the rate of onset and degree parallels the paralysis as a rule, so that when the part has completely lost its motor power it is likewise wholly insensitive, so that pin pricks

or transfixion may cause neither pain nor bleeding, and even red-hot irons may cause no flinching. Electric contraction, however, remains.

As previously stated, there are normally numerous "anesthesia zones" in hysterics, and certain persons by fortitude, practice or natural callosity can withstand pin pricking, thermal and other forms of painful stimuli, and for these reasons the response to such tests alone must not be regarded as wholly authentic or determinative.

The *distribution* of the anesthesia, like the motor involvement, bears no definite relationship to the anatomy of the part, and hence it may be very variable, but is likely to be segmental, especially when it occurs without paralysis. It is especially apt to invade the area ordinarily covered by a glove or stocking, and is then known as "glove anesthesia" and "stocking anesthesia" respectively; but any more or less geometric area may be outlined, intervening parts of identical innervation being wholly normal. Certain mucous membranes may also manifest like insensitiveness, notably that of the throat, nose, conjunctivæ, and the genito-urinary tract. These areas vary in their definite outlines from time to time and can be made to shift by electric and other forms of suggestion, and usually the anesthesia is absent during sleep.

Hyperesthesia is the reverse of the preceding, and it may be an independent manifestation or coexist with others; hyperalgesia is practically a synonymous term for this set of superficial painful sensations. Usually these areas are less confluent and predilect certain regions, as stated, notably along the spine, near the groin, and about the breasts, testicles, and scalp; in the latter region they are often said to be of a severe bony or nail-driving type, known as *clavus hystericus*. Some joints are frequently the seat of such painful sensations, notably the hip, elbow, and knee; these are then known as "hysteric joints" or "Brodie's joints," and as such may baffle diagnosis and treatment until search is made for associated hysteric manifestations. Contracture of the same joint is frequently associated. The contraction ceases often in sleep and always during narcosis, which may be induced for a test or treatment. I recall the case of a married woman who wrenched her hip at home by a sudden twist and fall. She was not completely disabled for a week later, and when she then came to the hospital for suspected hip injury there were no objective evidences of injury about the joint except pain on active and passive motion, and she remained abed and was little affected by numerous

diagnostic and therapeutic measures. She had several hysteric stigmata. Later her own physician assumed charge of her again, meanwhile having learned that her complete disability was coincident with a marital row. He thereupon threatened her with the daily application of the actual cautery and she promptly got well.

These cases of "hysteric arthritis" are less common than before the advent of *x*-rays, and fewer of them are now long treated for mono-articular rheumatism, specific, or even tubercular manifestations.

It is well to constantly bear in mind that *pain alone* is never an inflammatory manifestation, and that it cannot long genuinely exist without associated symptoms that soon stamp it as proceeding from physical and not from psychical sources.

Hysteric patches of pain may also be found on various mucous membranes, such as the throat, vagina, urethra, and rectum. Some of these give rise to contractions of the adjacent sphincters with many appropriate symptoms.

Many of these hyperesthetic areas are more painful to superficial than deep pressure, and the patient may scream from the slightest touch and yet thrash about in bed without complaint. On diversion, a great deal or all of the pain is absent, and for this reason and others this symptom must have ample corroboration and reinforcement before it is accepted as diagnostic of hysteria. The location of the injury frequently determines the site of the pain, and it is thus likely to simulate a neuritis or rheumatism in injuries to the extremities or the back, and in the latter region lumbago has to be differentiated also.

These patients claim much suffering and yet they do not look haggard or worn, and they sleep and eat well and maintain a good general appearance, and all of them exclaim most when the audience is of their seeking or to their interest.

Psychic Form.—Emotional manifestations are very common, and these may show extreme or all modifications between exaltation and depression, joy and sorrow, laughter and tears. The well-known "attack of the giggles," or "spells of weeping," or "fits of anger," or "fainting spells," and other evidences of the play of emotions may occur.

Introspection and *impressionability* are quite characteristic.

Memory deficiency is quite often asserted, and this is so marked and convenient at times that many of these people resemble plain liars. In the typical traumatic forms, events just before and just after the accident may be quite blurred, while all other events are recalled with relative clearness; the accident itself may be forgotten. This memory

deficiency, or amnesia, is often more an element of inattention than actual mental deterioration, and is characterized by the same lack of consistency and continuity as other hysteric symptoms.

Deficiency of will power, or *aboulia*, is quite common, and the patient lacks initiative and volition.

Catalepsy, *somnambulism*, *dual personality*, and *trance states* are exceedingly rare in traumatic forms.

Convulsive or *irritative seizures* may occur in two forms:

(*a*) *Hysteria minor*, in which, after some strain, excitement, or emotion, the patient feels a choking sensation in the throat (*globus hystericus*) or some other premonitory sensation, and this is soon followed by an irresistible desire to laugh or cry, to become jocose or angry, or a violent outburst of anger occurs, or a torrent of abuse is poured out without perhaps any warning or provocation. During the outburst the patient tosses or wanders about, and spasmodic or mild convulsive motions may occur. After the height of the relatively short attack is over the patient may be bathed in perspiration and fall asleep. Later, a large amount of pale urine is passed and the patient may feel comparatively well, although headache and weakness are usually complained of. Some manifestations are referred to by the patient or friends as "fainting spells," and in these there is a temporary unconsciousness ordinarily without any convulsive movements. These not infrequently occur during the course of an examination or in court, and they are characterized by sudden onset and slight, if any, preliminary excitement. The patient ordinarily is apparently perfectly well and suddenly falls into a chair or on a couch and remains quite motionless for a few moments, and then appears well again. Some of these attacks resemble the petit mal of epiplepsy, and they may be repeated many times daily under varying forms of stimuli, or there may be long intervals between them. The duration may be momentary, or such an "attack of hysterics" may last an hour or more. They rarely follow any set form and may be induced by many kinds of mental impression.

At one time a joke may induce the attack; at another, the element is sadness; or again, the mention of the accident may be the inducing factor.

(*b*) *Hysteria major* may begin like the preceding or start without any preliminaries and immediately the patient may become rigid, staring, intent, and usually falls, selecting some place that is conspicuous and free from danger or personal discomfort. After temporary rigidity, or without it, violent motions are made with the arms and legs and other parts of the body, which move in a more or less *tonic* convul-

sion. Efforts at restraint are resisted by almost prodigious strength as the patient grasps, pushes, shoves, bites, claws, and contorts about. The eyes are usually staring, open and rolling, and the antics may seem well directed and designed for an unconscious person. All sorts of poses and poises may be assumed and at times the body may rest on the head and heels (*opisthotonos*), or the reverse (*emprosthotonos*). The pupils are usually equally dilated. Respiration may temporarily cease long enough for cyanosis and great lividity to occur and the pulse may be rapid from the exertion. These rather slow motions of the limbs and other parts of the body may later become very rapid (*clonic convulsion*) and appear on one side or both and be epileptoid in appearance; but there is no such thing as hystero-epilepsy.

Such a procession may progress with an acrobatic display or a series of remarkable contortions and attitudes more or less suggestive. The duration may be a few minutes or an hour, and end only when physical exhaustion appears, and they may again recur after a period of sleep. There is never absolute unconsciousness in such a seizure, and it can often be aborted by various forms of stimuli, of which may be mentioned smelling-salts, ammonia, pressure on the supra-orbital or intercostal nerves ("the gridiron treatment"), or the application of vigorous slaps to the soles ("the policeman's tattoo"). Pressure on a hysterogenetic zone or the use of an electric battery may also be effective. The nausea and vomiting induced by a hypodermic of apomorphin is not only curative but also has a powerful deterrent value. Mental suggestion in the form of verbal threats, promises, or entreaties may stop some "fits." If the audience disappears, the attack often spontaneously subsides. Bystanders may be kicked, bitten, or scratched, but the patient is never self-harmed. Sometimes a period of delusion or hallucinations may follow, but generally the attack ends as suddenly as it began. The extraordinary poses and attitudes seen in some types of hysteria are rare in the traumatic forms, and, indeed, they are unusual in all forms in this country.

Recurrence is likely, and the patient can often induce an attack at pleasure, and many of them are able to ward off an attack by auto-diversion or will power. After the attack the patient is usually as well as ever, but occasionally a period of so-called "hysteric coma" may appear, and in this condition the patient may arrive at the hospital; some professional "fit throwers" always become "comatose" on the arrival of the ambulance, but they speedily revive if the surgeon in attendance recognizes them and threatens a police cell and not the anticipated ward bed.

Occasionally the seizure is followed by motor or sensory paralysis in one or more limbs; or if these have preceded the attack, they may disappear, and the "paralyzed" parts may move as actively as the rest during the convulsion.

Special Sense Forms.—Vision.—Defects of this sort are usually suggested by some slight injury about the face or forehead, or by the display incidental to an electric short circuit, or a bright flash or flame. "Shocks" from electricity and lightning are other sources. Anesthesia of the retina to light and color may occur, resulting in impairment of vision (amblyopia) or blindness (amaurosis). Ordinarily this appears in one eye, rarely in both. Examination of the eye may disclose normal conditions or ordinary derangements in nowise attribu-

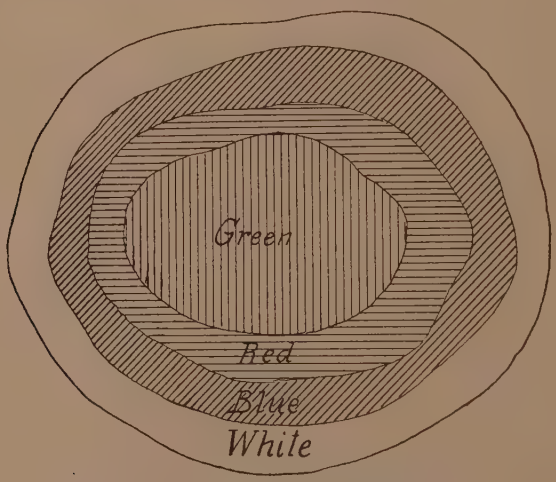


Fig. 522.—Visual and color field in hysteria.

table to the accident, and the majority of patients know nothing of their visual defects until these are disclosed by the examination. The affected eye and the areas of paralysis or anesthesia are usually on the same side. Perimeter examination shows that there is "limitation of the peripheral field of vision," and this is one of the pathognomonic signs of hysteria, as is also "reversal of the color field." The field of visual limitation usually does not exceed 15 degrees, and it constantly shifts and is rarely twice alike. If the limitation is marked it is ordinarily concentric in distribution.

This limitation of the scope of vision is usually associated with alterations in or reversal of the color scheme perception. Normally, of the "primary colors," violet is perceived in a relatively small cen-

tral area; green, red, yellow, and blue in progressively wider areas respectively; but in this condition the area for blue, instead of being the largest, may be contracted and fall within the red area, the others being correspondingly altered or reversed. The sensitiveness to red persists most, that to violet, green, and blue disappearing in the order named. As stated, this is a manifestation of anesthesia and becomes of functional importance in certain occupations. So characteristic are these visual disturbances of this disease that they are termed by Janet "hysteria's barometers."

The palpebroconjunctival reflex is usually absent in these cases, but true organic disturbances like hemianopsia and loss of the pupillary reflex do not occur.

These patients may have bilateral blindness and not know it until some definite examination discloses or suggests it to them.

Bailey states: "Hysteric patients in reality see, although visual perception does not become known to the higher consciousness. This hysteric amblyopia, like other hysteric symptoms, is actually false; although when the patient is conscious of it, it is real to him."

There are all sorts of hysteric subjective symptoms referable to vision, such as bright or dark lights, balls of fire, and other visual impressions. There are also various spasmodic affections or "tics," like winking or blinking, or spasm of the eyelids (blepharospasm). Involvement of some of the ocular muscles occasionally occurs, leading to squint and ptosis (usually unilateral). Diplopia may also infrequently appear. Pupillary changes amounting to sluggishness may occur from muscular tire, but the Argyll-Robertson pupil is never hysteric in origin.

Hearing.—This deficiency also is an anesthetic defect, and is usually found on the same side as the anesthesia or paralysis. It is rarely total, and ordinarily is unilateral, presenting impairment alike to bone and air conduction, and thus differing from pathologic deafness. It is less common than, but frequently corresponds and is associated with, the visual contraction, and while these patients have no structural deficiency, yet they do not actually hear. It is generally accompanied by anesthesia of the drum, external meatus, auricle, or other parts of the ear.

Speech.—This may be associated with visual and hearing difficulties and is wholly psychic, and ordinarily means that the muscles connected with phonation are paralyzed, spasmodic, or anesthetic. Such patients can make sounds, but are ordinarily incapable of articulation. This aphasia is usually sudden in onset, and may precede, follow, or be

associated with other hysteric manifestations. Paralysis of the vocal cords, and pharyngeal and laryngeal anesthesia can usually be demonstrated, and hoarseness or peculiar vocal sounds are often present. Dog-bites frequently suggest hydrophobic symptoms, like barking, whining, and salivation.

Smell and Taste.—There may be unilateral impairment of one nostril or a symmetric portion of the tongue, and then the corresponding portions of the mucous membrane of the nose, lips, and tongue are respectively anesthetic. This combination may exist alone, but usually is found associated with visual-auditory defects corresponding to anesthesia or paralysis of the same half of the body. This loss of smell (anosmia) and taste (ageusia) are obviously wholly subjective symptoms and hence difficult to demonstrate by tests; if, however, unusual or often vile smells and tastes produce tears or saliva, the degree of impairment is at least not very complete.

Visceral Forms.—Any organ of the body may be involved enough to suggest at first a true lesion, and the differentiation is made by the complex of symptoms and the presence or absence of hysteric stigmata. Many of the symptoms are often quite neurasthenic in type.

Heart involvement may be suggested by alterations in pulse-rate and attacks of precordial pain resembling angina pectoris.

Blood-vessel involvement may be suggested by cyanosis, edema, peculiar rashes and blushes, and other surface manifestations, of which dermographism (tache cérébrale) or urticaria are typical. Hysterics, as a rule, do not readily bleed, probably due to spasm of the coats of the vessels.

Gastro-intestinal signs such as nausea and vomiting, eructations of gas, perversions of appetite, epigastric or other "phanthom" tumors, and severe abdominal crisis-like pains, are the usual manifestations.

Kidney and *bladder signs* take the form of painful and irritative symptoms, but attacks of colic or changes in the urine are very rare, but polyuria or retention are common.

Respiratory changes are occasionally indicated by dypsnea, cyanosis, and rapid breathing. Hysteric coughing and hemoptysis occur infrequently.

Sphincters are never truly involved, but involuntarily emission of urine may occur as an index of lack of control; such escape of urine during emotion is not uncommon in many persons, notably young women. Rectal involvement is less common, and neither in this nor in vesical forms is there any great soiling or excoriation of outside parts. Anesthesia of the urethral and rectal mucous membranes is

generally coincident, and while the sphincters may be less taut than normal, they are never wholly without contractility.

Spasmodic urethral stricture is common, but that of the rectum relatively rare.

Equilibrium may be disturbed, leading to vertigo or instability when standing erect with eyes shut (Romberg symptom), and even gait defects of an inconstant and irregular form may occur. True incoordination is absent.

Mental deficiency never goes on to a true psychosis or insanity, and the patient's mind, indeed, may be preternaturally active; many a "genius" or "prodigy" is markedly hysteric.

Phrenasthenia, or mental weakness, is very rarely traumatic, and if it is, neurasthenia more than hysteria is at the basis.

Prognosis of the Traumatic Neuroses

The determining elements are largely alike in each neurosis, and they can, therefore, be considered together; they may be said to depend upon—

(1) The individual.
(2) The environment.
(3) The nature and extent of injury.
(4) The treatment.

(1) *The Individual.*—Neurotics, as has been stated, are often born and not made; the raw product already exists, and the exciting cause fashions it into some recognizable shape.

Poor heredity and equally poor psychical or physical poise and strength are a combination unfavorable to speedy recovery. The naturally "high strung" do not get well as quickly as the better balanced.

The extremes of age offer poorer prospects than the adult type. Women are apt to recover as quickly as men; in hysteria, males usually get well more promptly than females.

(2) *The Environment.*—If the subject can be isolated and freed from the attention of would-be advisers the outlook is excellent. Tact on the part of the physician and others is extremely important and the habit of optimism is nowhere more needed than in these ailments.

If the physician finds that the patient no longer imposes entire faith and confidence in him, his value is so lessened that he had better retire.

The *prospect of litigation*, as indicated, is a marked deterrent to recovery, and even in genuine cases serves to keep the patient alert

and alive to every change in symptoms. It is a constant source of worry and expectation and is probably as potent a factor as any in determining the outcome. Cases very rarely recover while adjustment is pending; but the vast majority of them respond very promptly when it is accomplished, and nearly all of them get well soon thereafter.

I have known of a case of a woman about fifty years old who had very marked evidences of major hysteria, and her trial was hastened in view of affidavits made by her attending physicians to the effect that she was soon likely to die. She was markedly emaciated and had well-defined contractures, with hemiplegia and hemi-anesthesia of the left side. Her voice was almost inaudible and she had numerous hallucinations and trances of a religious type. Originally she had fallen from a car, and the onset of her hysteric manifestations were associated with injuries to the back and legs which induced the suggestion of paralysis. She had been abed some four months when I saw her, and by starvation had become exceedingly weak. Her claim was adjusted and within a short time she was reported as having resumed her regular duties. Theoretically the outlook was bad in this instance, considering her age, environment, and a weakness greater than I had hitherto witnessed in a similar case. I once examined a young negress who had been in a collision of cars and who had received a few contusions of the scalp and other parts of the body. She promptly went into a trance on reaching home, and one arm and leg was anesthetic enough to permit her to be made "a human pincushion." Her doctor sensed the situation and stopped the "trance" with a syphon of aërated water, but she was anesthetic and abed when I saw her a few days later. Immediately after adjustment her doctor told me she got well enough to go to Coney Island on part of the proceeds. The first of these cases had received unremitting care from four doctors, two nurses, and many relatives, and day by day her condition got worse from too much attention. The second case was a splendid subject or "medium," and under different management was capable of developing almost any set of hysteric symptoms.

(3) *Nature and Extent of the Injury.*—How the accident happened and what it physically does are not necessarily determinative, because we have seen that grave injuries are generally free from functional nervous signs, and minor injuries are often full of them. Very little was heard of the "traumatic neuroses" among the survivors of the recent "Triangle fire" holocaust, although most of the young women employees were foreign born or their immediate descendants, and of

added susceptibility because of working conditions. Had these same employees, however, been subjected to the "fright and shock" incident to a falling-elevator accident in their own building, then the nervous claims would have been legion despite the marked difference in the grade of probable shock accompanying each of these accidents.

There is often no more reason for the development of the neuroses from a rear-end railway collision than from a fall on a banana peel. The extent of the physical damage, or the more or less tragic consequences leading to it, are no infallible estimate as to the development of the neuroses; without proper suggestion and environment they will not appear or disappear. I saw a marked case of hysteria, plus wilful exaggeration, developed by the fall of a small piece of plaster weighing a few ounces which struck a woman on her hat, and then on her face, while she was in an elevator. She was being treated for "spinal disease" because she said she could not move her legs or feel pins stuck into them. She was carried to court on a stretcher and got a verdict larger than if one leg had been actually amputated, and yet admittedly she had scarcely a mark on her face and was able to go home alone after being hurt.

If the patient has some actual injury, especially a fracture or some condition causing real pain or requiring dressings, the chances of hysteria developing are very remote; I do not recall any case of definite objective or serious injury complicated by hysteria. After the original injury has been cured, however, it is not uncommon to hear many neurasthenic symptoms related.

(4) *The Treatment.*—This is a major factor, and the more prompt the recognition by the doctor of the patient's susceptibility, the greater the probability of warding off later nervous developments.

Prophylaxis is exceedingly important, and the wise doctor after careful examination will positively assure the patient that "spinal injury," or "internal injury," or "brain damage" has not occurred, and that there is no good reason why recovery should not be just as prompt and certain as if the injuries had occurred in a way for which the patient was wholly to blame. It is suggestive that these neuroses do not occur at play, even though such sports as football, baseball, golf, tennis, bowling, wrestling, swimming, boating, and others have attendant injuries the equal of those for which somebody else is liable in damages.

A great many of these "nervous" symptoms would be checked promptly by less zealous attention and fewer visits from the doctor,

as very many of them would never be heard from a second time unless referred to by needless inquiry and aimless therapy.

Next to freedom from suggestion, the element of changed environment, as by isolation, is of prime importance. The sight of people with real suffering from actual injury is often a deterrent to the neurotic, and for that reason a hospital stay is very valuable and few cases develop there. A tactful nurse, attendant, or friend is of much help, and, of all places, the "calamity howler" has no place in the presence of a nervous patient. It is a strange thing that all physicians and most friends are optimistic in the sick-room, except when the neuroses are being treated; but in these, it is common in the hearing of the patient to parade all sorts of symptoms and predict almost fatal consequences.

My personal belief is that the vast majority of these neurotics are created by suggestion and nurtured by attention, and that the onset and cure are alike dependent upon improper treatment. That hysteria may occur in the absence of motive and be quite difficult to cure is wholly true; it is liable also to recurrences either in its original, added, or lessened manifestations. Recurrences, however, generally show some of the elements of the preceding attacks, although the dominant features may be the outgrowth of more recent mental assaults. Hysteria is more likely to end quickly than neurasthenia, and often a person "paralyzed for months" may regain use of the limbs in an instant from some sudden shock or fright, just as the onset of the trouble was due to similar causes. Recovery from neurasthenia is generally more gradual, the pains, aches, and incapacity becoming less marked slowly, or appearing only at times of stress and strain.

The neurasthenic may become entirely well, but the hysteric may continue to present the inherent "stigmata" throughout life, even though the "accidents" have disappeared.

The *duration of symptoms* cannot be foretold accurately. Marked manifestations of hysteria may disappear in an instant; or they may persist for years, but are practically never permanent. The cause, grade, or extent of these hysteric signs is no measure as to their duration, for a hysteric deafness may be more resistant to treatment than a hysteric paraplegia.

As indicated, traumatic neurasthenics develop and are cured more slowly, but the recurrence is less likely than in hysteria or non-traumatic forms of neurasthenia. These patients are quite unlikely to improve pending adjustment of their claims, but the very great majority of them get well thereafter. All the cases of hysteria that have come to my

immediate attention have recovered except one, and she had multiple sclerosis as well.

The outcome of the neurasthenia cases is harder to gauge because their complaints are based so largely on their own statements, and manifestly most of them are unwilling to admit recovery having asserted permanency and perhaps having received indemnity on that basis. But the fact remains that they are no longer idle or under treatment, and the inference is that working capacity at least has been restored.

True cases never lead to organic lesions such as insanities, and if these subsequently develop, the neuroses must be looked upon as premonitory and not initiating evidences.

It is not impossible for these functional conditions to coexist with organic disease, this being especially true of hysteria.

Treatment of the Neuroses

This presupposes that the diagnosis has been accurately made, and, as previously stated, most cases due to injury are a combination of neurasthenia and *some* hysteria, rather than the reverse.

Management may be (1) general and (2) local.

(1) **General Management.**—Early recognition of a "tendency toward nervousness" is very important, and this leads to caution in suggesting symptoms or their interpretation to the patient. If the atmosphere is such that the accident is the main topic of conversation, then a change of environment must be made so that the patient may not become a prey to self-imagining or that of others.

Isolation is valuable in most cases, and is most efficient when carried out by a tactful attendent in whom the patient has confidence.

Careful examination and investigation by the physician gives the patient a large sense of confidence and faith, but the opposite is attained if the examination is cursory. Neither too little nor too much attention must be paid to subjective complaints, but an explanation of them is always in order.

A frank talk with the patient will often allay suspicion and disabuse the mind as to feared symptoms or possible developments. In this respect the physician is guided by answering for himself and patient the question, "What usually and ordinarily happens under similar conditions?"

If possible, adjustment should be obtained promptly, as on this much of the subsequent course often depends.

In every family there is always some level-headed person on whom

the physician may rely, and to such care the patient should be left when possible. The less attention and chance for display the hysteric has, the less the manifestations; and the neurasthenic also needs more than one auditor into whose tired ears his woes may be repeated.

The neuroses comprise a group of players in which the neurasthenics do the talking and the hysterics the acting; hence the quality and quantity of the audience is very important.

The "rest cure" devised by Weir Mitchell is a very valuable method in many of these cases.

(2) **Local Management.**—*Pain* and *insomnia* will be the two chief symptoms requiring aid. It is to be remembered that a hypodermic of morphin is no more potent to the hysteric than sterile water; in fact, the latter is far more efficacious if administered with the dramatic detail so craved by such a patient. Therefore the relief of these and other allied mental symptoms must be largely by mental means.

Pain is treated by various external applications, hot or cold. The local use of the cautery is very effective in humbug and allied pains. Electricity, massage, baking, and hydrotherapy all have their place. It is unwise to rely on drugs, as theymay prove habit inducing and at best soon lose their effect. It is especially unwise to use the hypodermic with these imitative people.

Insomnia is best relieved by nightly warm baths or spongings, or by cold compresses to the forehead or nape of neck. A brisk body massage is quite effective in some cases. The suggestion that sleep will result after a planned treatment is part of the therapy.

Paralyses and *contractures* require no special treatment aside from massage, vibration, and electricity, but these must not be resorted to if they tend to aggravate existing symptoms or suggest others. Hypnotized and anesthetized patients are sometimes permanently relieved of these symptoms by thus demonstrating their non-physical existence.

Special sense defects are given the benefit of the suggestion implanted by electric or other forms of local treatment.

Convulsions are sometimes cut short by pressure on hysterogenetic zones or other painful areas, such as the supra-orbital or intercostal regions. Many fits stop just as soon as the audience departs. These attacks never harm the patient, and thus they can be disregarded. Vigorous use of cold or hot water or spirits of ammonia cut short many of them. A jet from a siphon of aërated water or a hose-pipe is quite effective. The hysteric will not have a "spell" unless the

surroundings are comfortable, and thus the environment again plays a prophylactic as well as a curative part. A girl with "highsterics" is less likely to encore her exhibition if the only applause is an old-fashioned spanking or a session alone in her room without food.

If "the punishment fits the crime" there is usually little necessity to again prove its punitive value.

Many of these people run the gamut of all sorts of treatment, and finally derive much benefit from adherence to some cult or "istic" belief. Shrines, relics and meccas from earliest times have thus worked wonders by faith and suggestion when all else has failed. The discipline and fixed attention of Christian Science may act admirably in such a "mind disease," and there is no question that "cures" and various "pathies" are active agents in some cases. Hysteria may be induced by the emotional strain of a religious "camp meeting" or cured by similar mental appeals. Psycho-analysis, and interpretation of symptoms thereby, may also act in the same way and be the starting-point of mental re-education leading to cure.

Great care is to be exercised so that no underlying pathologic condition is overlooked, and, indeed, a diagnosis of non-traumatic "hysteria" or "neurasthenia" is now being looked upon more and more as a cloak for ignorance, because the neuroses are often shown by careful analysis to be merely symptoms and not entities.

Differential Diagnosis

Hypochondriasis is imaginary illness, and is sometimes called "imaginitis" by persons familiar with accident claims. It presents verbal evidences only, and is associated usually with minor injuries, or is an acquired end-result after objective evidences of real injury disappear. Motive, as in neurasthenia, generally exists, and women are more commonly affected than men. All sorts of symptoms are charged to the accident, notably those referable to the cardionephritic, gastro-intestinal, and genito-urinary tracts. These people are generally well nourished, and a complete physical examination indicates that they are first-class life insurance risks. Any demonstrable defects are old and due to ordinary causes and perhaps became known to the patient only as a result of examination after the accident. The hypochondriac has often as many subjective symptoms as the neurasthenic, but has none or few of the objective signs of the latter, and wholly fails to demonstrate any evidences of the hysteric. Many of these people are chronic complainers and persistently have a "grouch," independent of any added exclaiming due to an accident.

Their speech and deportment makes the diagnosis easy in the absence of cardinal traumasthenia signs, and by questioning them they may be readily induced to add to an already long list of symptoms.

Malingering, or feigning of symptoms, is very common, and my experience is that it manifests itself under the following guises: (1) Absolute malingering; the fakir. (2) Traumasthenia plus malingering.

(1) **Absolute Malingering; the Fakir.**—Here the symptoms are purposeful and deliberately assumed with the idea of magnifying the condition and "getting more out of it"; in other words, the faking is consciously planned with intent to deceive.

These people do not look like persistent sufferers, and they are actively alert and watchful lest they are caught off guard; but if the examination is sufficiently thorough and prolonged, they either overact or underact to such an extent that detection is certain. If, however, the symptoms are limited (as an alleged paralyzed limb) it may be impossible for the examiner to make it functionate, and surveillance will be needed to verify the suspected faking.

Subjectively, complaint is oftenest made of pain, weakness, insomnia, anorexia, and impaired genito-urinary functions.

Pain, if real and prolonged, inevitably shows in the countenance and general appearance of the bearer. By resort to the "relocation test" the actual persistence of pain can be determined, and the fakir cannot accurately relocate spots previously marked as painful to pressure. A zone that is tender is moved with care and is suitably protected during every action, but the fakir forgets this when taken off his guard; for example, a back "too painful to move" is readily bent when a request is made to remove the clothing or shoes. Painful spots on the scalp and elsewhere will stand considerable pressure if the attention is elsewhere focused by identical pressure; in other words, a fakir's pain is not consistent or persistent and is out of all proportion to the severity of the original physical damage.

Weakness, if real and continuous, means flabby muscles and general lack of tonicity; the fakir is not infrequently of athletic type.

Insomnia shows in the face and cannot long honestly exist without giving objective signs.

Anorexia, if real, means malnutrition and generally atonicity of the stomach, with demonstrable tympanites and other signs.

Impaired genito-urinary powers show in flabby external parts, and when urinary action is abnormal the urine will be concentrated and perhaps otherwise altered.

Sexual claims are limited only by the imagination of the patient

and are manifestly hard to disprove; but lasting diminution of this sort is very rare even in profound traumasthenia. Lively cremasteric reflexes are usually incompatible with sluggish sexual functions.

Objectively, complaint is oftenest made of lameness and stiffness, paralysis (muscular or sensory), tremor, convulsions, and special sense defects.

Lameness and *stiffness* have usually a demonstrable source and are very rarely the only symptoms of real injury. Ordinarily they are claimed in association with or following an injury to a joint, notably the ankle, shoulder, knee, and hip. At first the fakir asserts that the part cannot be moved at all on account of the lameness or stiffness, but later most of them will admit some motion at least. This is especially true in the shoulder, where it is often asserted that motion to a right angle is possible, but not beyond. Many of these cases are immediately disproved when the joint is noted to move freely while the clothing is being removed. Nearly all of these patients voluntarily hold the joint rigid during attempts to move it further than they desire, and this purposeful contraction is never twice alike and is much too general to indicate involuntary spasm of muscle. Flabbiness of muscle and alteration in the appearance of the joint inevitably follow prolonged limitation of movement, and thus the absence of these or actual atrophy are suggestive. Motion is always more active when the patient is diverted, and on the pretext of examining the chest the examiner's head may be placed under the armpit, and by elevating the arm the "stiff shoulder" can be unsuspectingly raised often beyond former limits, and when this is accomplished it frequently will remain there an instant until the patient realizes what has happened, and then it is very promptly dropped.

A really lame and stiff ankle should offer difficulty when the shoe and stocking are removed or replaced, and some severe grades of lameness and stiffness should require a special shoe. If the patient is asked to walk backward, the genuine lame part will be favored and weight will not be placed upon it; but the fakir, thus taken off his guard, will use the good and bad extremity alike. This is a valuable test and was first called to my attention by Dr. C. S. Benedict, of this city.

A patient lying down with legs straight, when told to exert power to lift one hip against resistance will also involuntarily contract the thigh muscles of the opposite side; this does not occur when a fakir is attempting to demonstrate lameness or stiffness in the hip.

Paralysis.—Motor power may be claimed to be wholly or partly absent, usually the latter. The arm and leg are most often claimed

thus to suffer. A real condition of this sort necessarily must show objective signs, and in their absence the examiner can be certain of the mental origin of the condition, and by careful examination or directed observation may be able to demonstrate it to others. Disuse of muscle invariably means alteration in its contour and consistency, and this then becomes objectively visible and palpable. A sudden pinch or pin prick has made more than one "paralyzed limb" jerk or move, and likewise the cautery and electric battery have proved equally stimulative. Claims of paralysis in a hand or finger are very common, and when the lost power is complete or nearly so, some form of contracture is usually associated. In women, such claims are frequently made, even though ordinary gloves are worn, a thing manifestly impossible in genuine cases. Sometimes, if the paralyzed part is designedly placed in an uncomfortable position, the voluntary contraction maintaining the posture will so relax it that another and less cramped attitude must be substituted, and thus the deception will be uncovered. Genuine paralysis is usually so flaccid or spastic that persistent mimicry of it is difficult.

Sensory loss is usually claimed as existing in an arm or leg, and many fakirs are capable of withstanding rather deep jabs from pointed instruments and less often from objects of high temperature. This capacity is greatest when on guard, but the fallacy can sometimes be proved by suddenly jabbing an area originally claimed as anesthetic and observing the response. True lost sensation is rarely the sole evidence of injury, and when asserted as the only manifestation must be regarded with suspicion. Actual loss of sensory power presents no contraction, twitch, or reflex action on stimulation; the fakir braces for the expected attack, but the examiner will eventually gain some response in assumed cases. Many persons are insensitive to ordinary superficial pain either naturally or from training, and some of this may have developed from the school-boy trick of transfixing a finger-tip with a pin or needle.

Tremor in the fakir always gets worse when observation is expected; but if it is deliberately watched, the rate and extent of it will vary within wide limits and soon cease from fatigue. The assumed tremor of fingers will often promptly stop or markedly vary if the fakir is asked to demonstrate it by holding the arm out straight. Likewise, twitching, jerking, grimacing, and more or less choreiform motions will vary so much and so often that even the perpetrator of them may soon admit "they are worse at some times than others." The signature of a fakir may be perfectly legible even though

continuous jerking of the hand is alleged. A great many tremors are alcoholic.

Convulsions, fits, and other "spells," "attacks," and "seizures" are largely matters of convenience, and they are never attended by real unconsciousness nor does the facial appearance vary much. The pupils normally react, and any change of pulse and respiration is produced by exertion. Professional "fit throwers" and "dummy chuckers" are less common than formerly, largely because they find it does not pay; even the tyro ambulance surgeon recognizes them, and they go to jail and not to the expected hospital.

Special sense defects usually refer to aphonia and deafness, but these rarely last long and are easily disproved.

(2) **Traumasthenia Plus Malingering.**—These are the cases presenting some objective neurasthenic or hysteric signs, with many subjective claims that cannot be legitimately ascribed to them.

I am aware that exaggeration and perhaps even deception are part and parcel of hysteria; yet the cases I have in mind are not of a grave enough sort to develop these as part of their hysteria. Such a case may show some tremor, instability of muscle and the circulatory apparatus, and perhaps even have a few areas of anesthesia, and give the history of emotional upsets, and perhaps even an occasional "hysteric convulsion." At the time of the examination a host of dissociated subjective claims will be made, but the examination reveals practically nothing. Most of these patients are natural hysterics trading on their newly discovered deficiencies and are virtual malingerers so far as disability is concerned.

CHAPTER XXI

EYE AND EAR TESTS AND STANDARDS

RAILWAY employees and others are often subjected to examination as to visual and aural capacity, the requisite standards having been determined and fixed by such representative bodies as the American Medical Association, the American Ophthalmological Society, the American Association of Railway Surgeons, and adopted and put into practice by the American Railway Association and other large groups of employers.[1]

The usual requirements are herewith indicated, this standard being in general use on the largest railway systems.

At the end is attached a form of report that may be used by the examining surgeon.

RULES

1. The qualifications essential in certain positions must be determined by the examinations prescribed by these rules.

2. Application Blank, Form ———, must be used by candidates for employment and by those selected for promotion.

3. Candidates for employment or selected for promotion must pass the prescribed examinations and tests before being permitted to enter, except temporarily, upon the duties of the position sought.

4. The general mental characteristics and the bearing of the candidate must be noted on the application blank by the examiner.

5. Re-examination may be ordered at any time by proper authority.

6. Applications will be approved or rejected by proper authority.

PHYSICAL EXAMINATIONS

VISUAL QUALIFICATIONS

7. Examinations must develop—

(*a*) Sufficient acuteness of vision to clearly see the prescribed visible signals.

(*b*) Ability to clearly distinguish the colors of the prescribed visible signals.

7*a*. ACUTENESS OF VISION—REQUISITES.

CLASS A.—*Enginemen, Firemen, Conductors, Train Baggagemen, Brakemen, and Flagmen in Road and Yard*

SERVICE

Entrance to service.	Promotion.	Re-examination of those in the service.
$\frac{20}{20}$ in one eye and not less than $\frac{20}{30}$ in the other; tested without glasses.	$\frac{20}{20}$ in one eye and not less than $\frac{20}{30}$ in the other; tested without glasses.	$\frac{20}{30}$ in one eye and not less than $\frac{20}{40}$ in the other; tested without glasses.

[1] *Internat. Jour. Surg.*, Nov., 1907.

CLASS B.—*Signalmen, Signal Repairmen, and Telegraphers.*

Entrance to service.	Promotion.	Re-examination of those in the service.
$\frac{20}{20}$ in one eye and not less than $\frac{20}{40}$ in the other; tested without glasses.	Not less than $\frac{20}{30}$ in one eye and not less than $\frac{20}{40}$ in the other; tested without glasses.	$\frac{20}{40}$ in one eye and not less than $\frac{20}{50}$ in the other; tested without glasses.

CLASS C.—*Other Employees in the Engine, Train, or Yard Service, Car and Engine Inspectors, and Bridge and Track Foremen.*

Entrance to service.	Promotion.	Re-examination of those in the service.
Not less than $\frac{20}{30}$ in one eye and not less than $\frac{20}{40}$ in the other; tested without glasses.	Not less than $\frac{20}{30}$ in one eye and not less than $\frac{20}{40}$ in the other; tested without glasses.	$\frac{20}{40}$ in one eye and not less than $\frac{20}{50}$ in the other; tested without glasses.

CLASS D.—*Crossing Watchmen.*

Entrance to service.	Re-examination of those in the service.
$\frac{20}{40}$ with both eyes open, without glasses.	$\frac{20}{50}$ with both eyes open, without glasses.

In cases of failure of a candidate for re-examination under Class A, or for entrance to service, promotion, or re-examination under Classes B, C, and D to pass the tests when examined without glasses and when further expert examination shows that with glasses the tests can be met satisfactorily, the acceptance of the candidate is optional.

EQUIPMENT

1. A set of at least two standard cards of Snellen's test letters showing letters of various sizes, from 20 to 70 inclusive. The letters to be arranged in different order in the corresponding lines of each card.
2. A standard reading test card with matter printed in various type.
3. A test spectacle frame with opaque disk.

ADJUNCT

The following may be used if desired:
A set of test cards showing semaphores in various positions.

METHOD OF TESTING—LETTER CARD TEST

Place the candidate to be examined so that he will not face a strong light; cover one of his eyes with the opaque disk in the test frame; place one of the cards at a distance of 20 feet from him in clear light, but not in direct sunlight, and direct him to read the letters on certain lines as selected by the examiner, including the line marked 20. A portion of the test-card may be covered and the candidate required to read the remainder of the line

of letters, or certain letters at each end of the line may be covered and the candidate required to read the intervening letters. If he can read the letters on the line marked 20 correctly, substitute another card with a different arrangement of letters and test in a similar manner. If he reads the letters on the line marked 20 on both cards correctly, it indicates normal vision. If he cannot read the letters on the line marked 20, direct him to read the lines above 20 successively until a line is found which he can read.

Record in fractions the acuteness of vision as determined, the numerator being 20 (the distance at which the card is placed) and the denominator the number on the card showing the smallest size letters that he had read correctly.

Repeat this test with the other eye and record the results.

Mistakes of not more than three letters on the 20 line, two letters on the 30 line, and one letter on the 40 line will be considered as a satisfactory reading. Other lines must be read without error.

Reading Card Test

Direct the candidate to read certain letters or sentences from the standard reading test card and record the smallest size of print read correctly at the ordinary distance of from 14 to 18 inches. A portion of the test card may be covered and the candidate required to read the remainder of the paragraph. The candidates should be able to read the print in paragraph No. 2 of the standard card to pass the test satisfactorily. This test should be made without glasses, except at the age or under other conditions where the use of glasses is permitted.

7*b*. Color Perception—Equipment

One set of Holmgren's colored worsteds, as simplified by Dr. Wm. Thompson, tagged for reference by lettering A, B, and C and numbering 1 to 40.

Group A, containing the light green skein A, the similar shades numbered 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19, and the confusion shades numbered 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20.

Group B, containing the rose skein B, the similar shades numbered 21, 23, 25, 27, and 29, and the confusion shades numbered 22, 24, 26, 28, and 30.

Group C, containing the red skein C, the similar shades numbered 31, 33, 35, 37, and 39, and the confusion shades numbered 32, 34, 36, 38, and 40.

Adjunct

The following may be used if desired: A lantern showing a number of colored lights which can be varied in size and intensity.

Method of Testing—Holmgren Test

Place the whole number of colored worsteds on a table in good, clear daylight. Put the test skein A at a distance of about 2 feet from the other colors, and ask the candidate being examined to select from the heap of colors all that look to him like the test skein, and place them beside it. Have him understand that he is not expected to find an exact match for the test skein, but that he is to choose all the colors that appear to him of the same general color as the test skein, both those that are lighter and those that are darker in shade. If he does not easily understand what is wanted, let the examiner himself select the colors; then, having returned them to the general heap and mixed them thoroughly with the rest of the colors, let him call on the candidate being examined to repeat the selection. This demonstration will not enable a candidate who is defective in his color perception to select the colors correctly, and he may pick out as looking to him like the test skein A some greens and also some of the gray or brown confusion colors, which will appear to him of the same general color as the test skein, only varying from it in shade. Record on the form the

numbers on the tags of the colors incorrectly selected as being similar to the test skein A, and also note whether the selection is prompt or hesitating, by writing the letter "P" or "H" on the line opposite each of the names of the colors as printed. Return all the colors to the heap and mix them together, then place the test skeins B and C successively apart from the rest and have the candidate being examined select, as before, all the colors that look to him like each skein, and record the results as for skein A.

No names should be mentioned in connection with any color in the above worsted tests, which should be based only on a comparison of colors.

If the candidate being examined selects as looking like the green test skein A any of the reds, or as looking like the rose test skein B any of the greens, he shall be rejected.

If the candidate for employment selects some of the grays or browns as looking like the green test skein A, or some of the grays, blues, or violets as looking like the rose test skein B, the candidate shall be rejected. If a candidate for promotion or re-examination makes such a selection, full report shall be made and left to the oculist for decision.

The selection by the candidate of one of the "colors of confusion" (even numbers 2 to 20) as matching test skein A indicates color-blindness. The failure to do this, but a manifest disposition to do so, indicates feeble color perception; making correct selection to match test skein B, having failed to match test skein A, incomplete color-blindness is indicated. But should he in this test select the purple, the green, and gray shades also, or one of them, complete green blindness is indicated. The test with skein C (which is applied only to those who are color-blind as to green or red) should be continued until the candidate under examination has selected the specimens of or a greater part of the skeins belonging to this color, or else one of several "colors of confusion" (even skeins 32 to 40). In this test red blindness is proved by the selections, besides the red shades, of olive green and dark brown shades of a darker quality than the red test skein. Green blindness is proved by the selection of similar confusion colors, but of a quality lighter than the red test skein.

Aural Qualifications

8. Examinations must develop ability to hear distinctly.

Equipment—Adjunct

The following may be used if desired: A ratchet acoumeter.

Method of Testing

Place the candidate at a distance of 20 feet, with one ear toward the examiner; have him close the ear furthest from the examiner by placing the finger over it, then let him repeat aloud the words or numbers spoken in a conversational tone by the examiner and record the distance in feet at which they can be repeated correctly. Have him turn the other ear toward the examiner and repeat the test.

Candidates for employment will not be accepted unless able to hear ordinary conversation the full distance of 20 feet.

No candidate for promotion or re-examination can be considered to have sufficient acuteness of hearing who is unable to repeat, with his eyes closed, words or numbers spoken in an ordinary conversational tone of voice at a distance of 10 feet.

9. Re-examination for acuteness of vision, color perception, and hearing shall be made at periods of not less than three years; and after severe illness, injury, or in employees addicted to alcohol.

10. If upon re-examination for acuteness of vision, color perception, or hearing an employee who has been at least three years in the service shall fail to pass the prescribed tests, if he so desire, he may be accorded a field test under service conditions. If he is able to pass the field test successfully, and upon the approval, after examination, by the company's oculist, he may be retained in the service.

We also suggest the adoption of the following application blank, to be known as Form ———, for recording all visual and aural tests, and that all visual and aural tests be made by regularly appointed oculists.

FORM ——

——— *Railway*

DIVISION..... .....19.....

RECORD OF EXAMINATION OF VISION, COLOR-SENSE, AND HEARING

Name.....Age.....
Employed as.....
Applicant for.....
Original Examination. Re-examination for.....

ACUTENESS OF VISION

	Without glasses.			With glasses.		
	Right eye.	Left eye.	Both eyes.	Right eye.	Left eye.	Both eyes.
Distance at which standard test-type are read.....						
Smallest line of standard test-type read correctly.....						

RANGE OF VISION

	Without glasses.			With glasses.		
	Right eye.	Left eye.	Both eyes.	Right eye.	Left eye.	Both eyes.
Least number of inches at which type 0.5 on test-card are read.....						

FIELD OF VISION

Right eye.....good.....bad. | Left eye.....good.....bad.

COLOR SENSE

TEST-SKEIN SUBMITTED.	NUMBER SELECTED TO MATCH.
A.—Green.	.....
B.—Rose.	.....
C.—Red.	.....

Flag Test.....
.....

Lantern Test.....

PROMPT.	HESITATING.
.....	.....
.....	.....

HEARING

	Right ear.	Left ear.
Watch	.....inches.	.....inches.
Ordinary conversation	.....feet.	.....feet.

Remarks.....
.....
.....
Approved.
Rejected.

.....
Examiner.

When an examination is made of an injured person the following elements in reference to eyes and ears should be kept in mind.

EYES

Lids.—Open or shut; normal in color or ecchymotic; normal in size, swollen, or retracted.

Eyeball.—Normal, scarred, squinted, receding or protruding.

Conjunctiva.—Normal, ecchymotic (diffuse, localized, crescentic, or semilunar).

Cornea.—Normal, scarred, irregular, opacities.

Pupil.—Normal, contracted, dilated, action to light and accommodation.

Vision.—Fingers counted at 18 inches; fine type read with either eye; restriction of visual field.

The main things to determine are the general appearance of the eyeball, the presence or absence of scars or squint, and the response of the pupils to light and accommodation. Opthalmoscopic examination will give valuable evidences of intracranial tension and may be one of the earliest indications of pressure, as from hemorrhage or edema.

EARS

Externally.—General conformation and signs of injury.

External Canal.—Normal or lacerated; bleeding; serous effusion; wax; furuncles; neoplasms.

Drum.—Normal, thickened, or retracted; open, scarred, or inflamed.

Mastoid.—Normal; ecchymotic; tender; swollen.

Hearing.—To ordinary and whispered voice at varying distances; with one ear plugged; tuning-fork and whistle tests.

Do not fail to examine the nose and throat for possible naso-pharyngeal sources of aural trouble, as the vast majority of ear defects originate therein.

A good test for hearing is known as the "stethoscope test," and in making this the end pieces of the stethoscope are placed in the patient's ears, the other end passing behind his head. The examiner holds a watch against the "bell" part of the instrument and asks the patient to tell in which ear the ticking is heard, and then the rubber tubing is pinched on alternate sides and the answers verified while the sound is transmitted along one tube only.

Another method is to apparently examine the scalp for tenderness and block the *good* ear with the hand or finger, meanwhile keeping up conversation, and if the patient answers when thus off guard the injured ear cannot be really much damaged. Catarrhal deafness from old nasopharyngeal or other causes is quite likely to show diurnal variations depending on weather and other conditions. In middle-ear disease from "catarrh," air conduction is better than bone conduction; but when the deafness is due to auditory nerve damage, bone is poorer than air conduction. In the former type of deafness, hearing is best in noisy places and is improved by inflating the drum; in the latter type, the reverse pertains.

CHAPTER XXII

X-RAYS; *X*-RAY BURNS

X-Rays

RÖNTGEN, of Wurzberg, in 1895 gave the first practical application of Crookes' tubes to medicine, and since then vast progress has been made with this valuable diagnostic agent.

It is to be recalled that the rays portray outlines of the denser tissues and that they are in the truest sense shadow-pictures or silhouettes, and to that degree capable of distortion and misinterpretation unless every care is taken.

In traumatic surgery the *x*-rays are of greatest value in fractures and dislocations and in the localization of foreign bodies, and to a lesser extent in various other lesions of bones, joints, and soft parts.

Fluoroscopic examination is not regarded as wholly reliable, and for that reason is not much used except as an emergency measure or in connection with an actual *x*-ray plate.

Radiographic examination or the actual photograph is the method of choice, and the product is known respectively as a *radiograph*, *radiogram*, *skiagraph*, *skiagram*, *röntgenograph*, *röntgenogram*, or, more commonly than all, as "an *x*-ray plate."

Use in Fractures and Dislocations

For the purpose of **diagnosis** it is extremely valuable, especially in obscure cases; but it is of even greater value in determining the outcome of attempts at reduction or setting. When only one series of plates can be obtained, I am in the habit of advising that the *x*-ray examination be made for the purpose of ascertaining the accuracy of **treatment** more than for the accuracy of diagnosis.

Precautions must be taken so that no false shadows are cast, and for that reason it is always advisable to radiograph the injured and the uninjured parts on the same plate if possible, making an antero-posterior and a lateral exposure when feasible. This means that four images will be obtained, two of the normal and two of the abnormal, each taken from the same angle at the same time by the same operator and the same machine. If this is not done, and if the tube

is not directly at right angles to the object and the latter as close as possible to the plate, all sorts of distortions are possible.

Some of these errors were long ago brought out by Lewis G. Cole in his article "Skiagraphic Errors; their Causes, Dangers and Prevention."[1] Among other experiments, he so radiographed his own wrist that the plate could be said to indicate a healed Colles' fracture, although he never had such an injury.

The plates are better indications of the actual situation than prints made from them, and neither plates nor prints should be chemically or otherwise altered in attempts to "touch up" or "tone" them, unless some predetermined reason so demands.

Aside from the mere *taking* of the radiographs, the question of **interpreting** what they show is an art in itself, and should not be undertaken lightly by a novice except in perfectly apparent cases. This is especially true in determining the relation of certain irregularities on long bones or suture lines and pacchionian bodies in the skull. The interpretation of the radiograms of the deeper joints, like the shoulder and hip, may be very difficult, and the condition of the spinal column and the sacro-iliac joint may baffle the most expert.

Radiology has become a definite specialty, and is of greatest value when the radiologist is a trained physician who has opportunity to see and study his cases clinically as well as in the *x*-ray laboratory.

The *x*-ray findings should bear some definite relationship to the clinical findings, and one should corroborate the other.

Epiphyseal separations are often confusing, and I have seen plates introduced in court to indicate fractures when, in reality, the disjunction was an unjoined epiphysis and diaphysis, not recognized by an inexperienced physician. In cases like this and many others a comparative view of the uninjured part would clear up the difficulty.

Medicolegally it is to be remembered that *one* plate of a part may show little or much, and that deductions from it may be quite untrue unless a plate of the uninjured portion is taken in the same axis. As already stated, two plates respectively of the injured and uninjured side afford the best evidence, just as a full-face photograph may show one type of features and a side or profile view an altogether different aspect.

The *x*-ray appearance following a fracture may be such that good function would seem most unlikely; but this is by no means true, as there is often a wide variation between *x*-ray findings and actual functional or clinical results. For this reason the exhibition of

[1] *New York and Philadelphia Med. Jour.*, March 26 and April 2 and 9, 1904.

x-ray plates may be quite misleading, if not actually prejudicial, unless accompanied by the statement that they nearly always make the part *look* worse than it *acts*. In many instances a doctor is sued for malpractice because the *x*-ray appearance indicates much irregularity and perhaps even malalignment, even in the presence of an excellent cosmetic and a perfect functional recovery. For this and other reasons a patient should be forewarned that the radiogram may often show much distortion that will not in the least affect the actual outcome. The same facts should be made known to the court and jury in malpractice and negligence suits.

Duration of callus is variable, and the less the original displacement and the more exact the setting, the less the callus. Large bones, like the shaft of the femur, may give *x*-ray evidences of callus for years, and this may also be true of smaller bones in which union has been malaligned; the clavicle is an example of this last group. Fractures of the ribs may fail to show callus even after three months if there has been merely a "crack" without actual separation or overlapping of the fragments.

Prints are not as good exhibits as plates, and the latter should always be free of "fogging" or other imperfections. The use of films instead of plates will prove valuable if they can be further perfected, and the Coolidge tubes are said to promise much advance over those now in use.

Localization of Foreign Bodies

Foreign bodies, like needles and other materials, in the hand and elsewhere are best located by stereoscopic plates. In the same manner bullets are located. Various methods are used to locate bodies by criss-crossing the skin over the affected part with fine wires or layers of bismuth or solutions of silver nitrate. Other more or less practical means are also employed for the same purpose, of which the principle of triangulation may be mentioned.

x-Ray Burns

These are now practically restricted to *x*-ray laboratory workers, and are rare even among members of this group who have observed the precautions adopted in the past five years particularly. Patients are now rarely burned except when repeated exposure becomes necessary for therapeutic purposes. The exposure for the average *x*-ray work incident to traumatic surgery is so short that burns practically never occur unless the patient has some peculiar idiosyncrasy.

Varieties.—Three grades are described, as in ordinary heat burns, and all are characterized by late onset, and the symptoms may not appear for as long as three weeks, and it is quite the rule for no "reaction" to occur for several days after exposure.

First degree forms cause redness, burning, itching, and some swelling of the part and later the "skin peels off." It is closely allied to sunburn and is, in effect, a dermatitis.

Second degree forms are aggravations of the preceding, with the formation of blebs in addition. When these are broken the involved part is red and raw and may become eczematous.

Third degree forms involve the deeper layers and cause eschars and ulcers, and often areas of sloughting and gangrene. This is an exceedingly serious situation, and large areas of subcutaneous sloughing may occur with much pain and systemic prostration. The process may lead to burrowing and sinus formation from a mixed infection.

Chronic burns were common among *x*-ray workers some years ago, but they are fortunately rare now. In this city I know several pioneers in the field who bear the marks of their early work in the form of atrophied, scarred and crooked fingers, scaly hands, and brittle or ragged nails. Some of the victims develop warty growths on the fingers somewhat allied to epithelioma, and at times the condition is reawakened so actively that they must cease work for a period. This form of irritation is very insidious in onset and many months or even years may elapse before ulceration follows the initial dermatitis. Carcinoma has occasionally appeared in such a chronically inflamed area. Sterilization may be produced in either sex by these continued or repeated exposures.

Treatment.—The first and second degree forms are treated like other burns. The ulcerative third degree form is exceedingly hard to manage, and the part may have to be exsected and skin-grafted before healing occurs. In some instances amputation may be required.

Of late, radium has been used with much success in some of these cases, and recently I saw one radiologist who was apparently completely relieved of numerous warty growths by this agency.

Needless to say, the essential of treatment is to avoid contact with the rays, and this has a prophylactic as well as curative value.

CHAPTER XXIII

MEDICOLEGAL PHASES

ACCIDENT cases are very frequent sources of litigation, and the attending or examining physician may be called upon to give evidence before, during, or even after such a case has been submitted to a court or jury.

Some injured patients may come under the Compensation Law now operative in twenty-four or more states, and others are covered by the policies of accident, casualty, or insurance companies.

Because of the possibility of legal procedure it is prudent for the attending physician to make careful notes of every accident case coming to his notice, so that a complete history may be available when needed. Such a history should contain a full account of the manner of the accident and the immediate and intervening objective and subjective symptoms and treatment. The presence or absence of initial unconsciousness should be noted with great care, and an attempt must be made to determine whether such an unconscious period was due to syncope, fright, shock, bleeding, concussion, or other forms of head injury. In this latter connection it may not be amiss to repeat that an essential feature of concussion is immediate unconsciousness ordinarily associated with vomiting.

In obtaining a history of suspected bone or joint injury it is quite important to inquire whether or not any manipulation of the injured part had been made by the preceding physicians in attendance. This is particularly valuable, for example, in determining such a condition as dislocation of the shoulder, because the majority of such injuries and many others may fall into the care of the family or attending doctor after initial treatment by an ambulance surgeon or another physician summoned in the emergency. If the patient is able to describe the maneuvers made by this first doctor in setting a dislocation or fracture much valuable information may thus be supplied, and the diagnosis will be finally corroborated by the existing findings.

In making the diagnosis too much attention must not be given to *subjective* complaints unless they have an *objective* basis, for it is to be remembered that a *real hurt or injury always has some objective manifestation*, and that many genuine *subjective* complaints can be made *objective* by suitable examination tests. Of these subjective complaints,

pain is the commonest; but long-continued pain shows in the countenance, and the affected parts are automatically spared and favored by every move or action of the patient. Areas of pain on pressure should be relocated with accuracy, and thus tender spots on the spine previously indicated by ink markings should remain tender each time they are touched in genuine cases.

Objective findings should be noted in detail, and when possible dimensions should be recorded. A diagram is a great help, and, however crude, it serves best to revisualize the conditions after a lapse of time.

Disused parts waste, and for that reason *atrophy* is a most important finding in connection with injuries of limbs; flabbiness and changes of skin texture are correlated findings.

The history should also contain a record of the treatment and notes as to the progress of the patient from visit to visit. In cases of fracture and allied injuries, tracings or prints from *x*-ray plates are very valuable. Laboratory findings are also added, notably blood, urine, and sputum analyses.

The history should contain a note as to the period of total and partial disability and a statement as to the period abed and indoors.

The **period of total disability** means the time during which the patient was wholly incapacitated and entirely unable to perform any regular or substituted duties.

The **period of partial disability** means the time during which the patient could perform some or all of the regular duties. Obviously this disability period depends primarily upon the extent of the injury, but also to a large degree upon the occupation, age, station in life, and general mental and physical make-up of the individual.

For example, a laborer with a fractured ankle might have a period of total disability of ten or more weeks because his work required him to use both legs, but a bookkeeper with the same injury might be able to do some work within a few hours, and thus would have practically no period of total disability. But if the injury was a fracture of the wrist, the situation might be reversed in these two preceding occupations, for then the laborer could be put to work as a flagman, but the bookkeeper could do little or nothing until his fingers were free to write.

The age, station in life, physique, and mentality of patients may also be factors, and, as a general rule, the higher the station in life and the mentality, the less complete and prolonged will be the disability.

Documents Relating to the Condition of Patients

The attending doctor is often asked to furnish a written statement as to the extent of a given injury and the probable period of disability. This may be for presentation to an employer, accident or insurance company, benefit organization, compensation commission, or judge or court. In many instances printed forms are furnished, and the careful physician will preserve a duplicate of this or any other certificate furnished.

When no specified form is requested, the language of the certificate is usually about as follows:

This is to certify that.....has been under
(Name of patient.)

my care from.....to date and his injuries consist of.....
(Date of first visit.)

.....He will be totally disabled about.....

and partially disabled about.....

(Signed).....M. D.

(Date)..... (Address).....

This form of report may be amplified if desired, and if for any reason a serious outcome is to be feared that fact should be stated.

Many of the printed forms furnished by accident and insurance companies are needlessly prolix and call for separate answers to the same general line of questioning. But despite this the physician should aim to give the desired information as completely and promptly as possible, so that his patient may not subsequently suffer from delay or financial loss.

Occasionally it may be difficult to answer printed questions such as this, "Is the condition of the assured, your patient, wholly and solely due to this accident independent of any other previous or subsequent accident or illness?"

If the patient has an old cardionephritis, or has developed delirium tremens, or has syphilis or varicose veins, and any or many of these complicate the original injury, it may be quite hard to answer such a query categorically. In such an event the physician should make whatever explanatory note he desires, always having in mind absolute truthfulness and fairness, with no intent to become a party to any deception, but with every desire to protect his patient in any legitimate manner.

Compensation Law Cases

In New York State the law allows employees sixty days, medical care and attention if they are injured during the course of their employment. The operation of the medical part of this law is similar in many of the twenty-four states now enforcing it, and a typical form of report is shown on page 721, this being the blank used in New York. The reverse of the form has space for diagrams.

Many employers will provide light or special work for employees during a period of convalescence, and the attending physician should take advantage of any such opportunity because it will allow the employee to get a higher money allowance and also keep his mind and body occupied.

Malingering and exaggeration will prevail to some extent within and without the terms of this law, but repeated, full, and complete examinations will diminish cases of this sort. When the physician is in doubt as to the genuineness of symptoms in such a case he should ask himself, "What usually and ordinarily occurs when an injury of that sort happens and there is no legal liability?" It is almost a maxim that subjective complaints are exceedingly rare unless the injury is being made an item of gain, financial or otherwise. Hurts received in sports, or those due to the carelessness or ill fortune of the recipient, are usually recovered from when objective evidences disappear; but identical hurts, which are being charged to the financial account of another, are rarely wholly relieved until adjustment is made.

As physicians, we all of us know the usual and accepted average disability of the daily run of injuries; but if for any reason this average disability period is prolonged there must be some reason for it. Such a valid reason, for example, may be (*a*) undiscovered associated injuries; (*b*) the treatment; (*c*) constitutional frailties that impair reparative powers; (*d*) complications. In the absence of these demonstrable or objective reasons there can only be non-demonstrable or subjective reasons that are in the largest number of cases wholly mental, and thus either imaginary, exaggerated, or feigned. But the physician must not regard all subjective symptoms as wholly feigned or exaggerated, for many of them are the legimate and accurate expression of objective manifestations; however, if the subjective complaints have had no reasonable objective basis, and if they are varied, dissociated, and have no anatomic or surgical relationship to the original condition, then they must be regarded with suspicion and labeled accordingly.

Form C-4.

STATE WORKMEN'S COMPENSATION COMMISSION

Principal Office: The Capitol, Albany, N. Y.

New York Office: 1 Madison Avenue

BUREAU OF CLAIMS

Claim No._____

Case of_____

ATTENDING PHYSICIAN'S REPORT

All questions in this blank should be answered, and the report should contain an account of all injuries, no matter how trivial. Fill out blank in ink, using pen or typewriter, and mail promptly to the Commission at its New York City Office.

1. Name of injured person_____ Address_____
2. Date of accident_____ 191____ at_____ M. Was first treatment rendered by you?_____
3. If not, by whom?_____ Address_____
4. If an assistant, consultant or anaesthetist was necessary, give name and address_____
5. Who furnished necessary medical supplies?_____ Was a nurse ordered by you?_____
6. Name of nurse_____ Address_____
7. Was injured person removed to hospital? _____ Name of hospital _____ Address_____
8. Give an accurate description of the nature and extent of the injury_____
9. Describe the treatment_____
10. Are the symptoms from which he is suffering due entirely to this injury?_____
11. Is he able to attend to any part of present or any other occupation?_____
12. Has the injury resulted in a permanent disability?_____ If so, what?_____ (Permanent disability, such as loss of whole or parts of fingers, etc., must be accurately marked on diagram.)
13. Has previous sickness or injury contributed to his disability?_____ If so, to what extent?_____
14. Is there evidence of syphilis?_____ Tubercular infection?_____
    Alcoholism?_____ Any infectious disease?_____
    Occupational disease?_____ Neurasthenia?_____
    Hypochondriasis?_____ Hysteria?_____
    Exaggeration?_____ Is there evidence of malingering?_____
15. For what period, from the date of accident, is disability likely to exist?_____ weeks_____ days.
16. State, in patient's own words, how accident occurred_____
17. Remarks_____

_____
Attending Physician.

Graduate of_____ Year_____

Date_____ N. Y., 191____ _____
(Address)

Fig. 523.

Elsewhere I have ventured to classify some of these commoner subjective ailments with suggestions as to the means of testing their reality. (See pages 702 et seq.)

ACCIDENT INSURANCE AND CASUALTY COMPANY CASES

These are generally of two sorts, one in which the patient holds an "accident" or "health" policy (or a combination "accident and health" policy); the other in which a policy covers the holder in case of accident to others. In each of these classes the basis of the procedure is the extent of the physical damage as certified to by the physician.

Many of these "accident" and "health" policies cover only certain specified manifestations of injury or disease, and the physician is often besought to make his diagnosis fit the policy rather than the pathology of the case in hand.

Various printed forms are provided to be filled out, and they are all of a type similar to the following:

CERTIFICATE OF ATTENDING PHYSICIAN.

*I Hereby Certify, that*_____ *of*_____
(Name of Claimant.)

*has been under treatment by me for*_____
(If for disease, state its precise nature.)

*I was first called to attend him on the*_____ *day of*_____ *191 , and continued to attend him at various times until the*_____ *day of*_____ *191*

*The symptoms and physical signs which existed during his disability were*_____

*The treatment consisted of*_____

*Surgical operation, if any*_____
(If disease necessitated surgical operation, give date and character of same.)

TOTAL DISABILITY

I Further Certify, that, solely in consequence of the illness above described, and independently of all other causes, he was totally disabled, that is, wholly and continuously prevented from performing any and all duties pertaining to his occupation above stated, during the space of _____ *weeks and* _____ *days, from* _____ *191 , at* _____ *o'clock* _____ *M. to and including* _____ *191 , at* _____ *o'clock* _____ *M.*

PARTIAL DISABILITY.

I Further Certify, that, solely in consequence of the illness above described, and independently of all other causes, he was partially disabled, that is, continuously prevented from performing important duties pertaining to his occupation, so that he sustained a loss of at least one-half of his business time each day, during the space of _____ *weeks and* _____ *days, from* _____ *191 , at* _____ *o'clock* _____ *M. to and including* _____ *191 , at* _____ *o'clock* _____ *M.*

*His present condition at this date is*_____
(State here what the actual condition is and the prospects of complete recovery.)

*Dated*_____ *191*____

Attending Physician.

*I was graduated by*_____
(Post Office Address in full.)

*In the year 18*_____

F632-A

Fig. 524.

If for any reason the insurance carrier is dissatisfied with the medical information first furnished, a further request is then made to the physician for additional information, and this request may be repeated several times, and the physician usually finds that the terms of the policy require him to answer in the interests of the patient. In case of death these insurance carriers require a medical certificate as a part of their "proofs of claim," and this is generally on another printed form.

The physician will save the patient and himself considerable annoyance and delay if the first certificate is answered at great length.

In cases of this sort no claim of professional secrecy is available because the patient has already disclosed the nature of the injury or disease, and, in addition, the certificate is made at the request of the patient or a representative, and further, the terms of the policy allow the insurer to obtain such information.

In the majority of cases of injury there is little room for controversy in answering some such interrogatory as "Were the injuries solely and wholly due to the accident in question?" However, if the patient had, for example, a stroke of apoplexy, and in falling struck his head and received a scalp wound or a fractured skull, it may be rather difficult to answer a question of that sort, and equally difficult at first to say whether the paralysis came from the apoplexy or the fractured skull. The differentiation here should not be difficult after a few days, and in that interval the prudent physician will indicate on the certificate any existing element of doubt.

In the event of death the terms of the policy often allow the insurer to obtain an autopsy by a physician of their own selection, and this is usually performed in the presence of the attending physician. The exact cause of death may or may not be agreed upon; if not, the case may then be carried to court.

Aside from apoplexy, there are numerous other medical conditions that are sometimes sought to be charged up to an accident; of these may be mentioned cardionephritic and arterial disease, and liver, lung, stomach, and intestinal conditions, all of which are classically regarded and recognized as being due to intrinsic and not extrinsic causes. Better class physicians do not, for instance, ascribe to any isolated or single act of violence such an improbable condition as endocarditis; yet I have known of several cases in which a blow on the chest wall, with or without fractured ribs, has been the ascribed cause of cardiac disease. Any such opinion as this, subscribed and sworn to by an attending physician, is but an invitation to refuse the claim

and submit the patient to the examination of a physician of recognized standing.

Furthermore, the attending physician must be on guard and not subscribe to any unusual or irregular sequence of symptoms merely because the patient wishes to come within the prescribed limits of some policy; such stretches of medicine and surgery do no credit to the profession, nor will such tactics often profit the insured, and they are quite sure to strain the scruples of all concerned.

Relation of Injury to Disease

At times the physician will be in doubt as to what relationship, if any, exists between an ancient disease and a recent injury.

For example, a patient is known to have locomotor ataxia and, on occasions, treatment has been given for this condition and the essential cause is known to be syphilis, the practically universal producing factor in this widespread lesion. At times this patient, like most of his kind, has periods of accession and remission, but nevertheless the ailment is progressing. Perhaps the patient has not been examined for some time, and may or may not be under more or less active treatment. An accident occurs in which this patient falls or receives a blow, the injury sustained being perhaps inherently trivial and often the outcome of the patient's ataxia. But because of the previous poor physical state of the patient due to the old ailment, there is precipitated a period of accession of symptoms and the patient may even be rendered wholly ataxic for a period. The question then arises as to the responsibility of the accident for "lighting up" or "aggravating" a condition known to be of itself independently progressive.

The same situation may arise in certain cases of arteriosclerosis and its results, and in nephritis, endocarditis, tuberculosis, diabetes, prostatic disease, and a large number of chronic and naturally progressive diseases.

It is a known fact that serious injury is not well borne by a physique already undermined by organic disease, and thus many accidents can be justly accused of adding an unfavorable element that may provoke an access of symptoms; hence, in a case of the type under discussion the nature and extent of the injury would be very important, as obviously the more serious the injury the greater the probability of affecting the disease.

The type, extent, and duration of the old lesion is also important, and in a general way it may be asserted that the accident will or will not be a *contributory* cause in direct proportion to the extent of the

injury and the duration of the disease. In other words, the injury will rarely be the *primary* or *initiating* cause, but may be a *secondary* or *contributing* cause of an accession of symptoms that may aggravate a previously existing condition. Of itself and independently the accident and the attendant injuries would not of themselves produce the existing symptoms, but combined with the old and perhaps more or less latent disease the clinical picture is easily explained and accounted for.

How much responsibility is to be attached to the disease and how much to the accident is, therefore, one of degree, and this is to be determined by the elements named above. We, however, must not lose sight of the well-known fact of experience that organic disease may be apparently latent and yet be actively progressing independent of any extrinsic causes, accidents or others. It is an every-day medical occurrence that cases of supposedly checked or quiescent arteriosclerosis, endocarditis, nephritis, diabetes, gastric, intestinal, and other troubles may suddenly and without any apparent or ascribable cause result even in death.

Summated, the whole matter resolves itself into the clinical fact that many patients with organic disease are potentially poor risks, and may be at any time, from more or less definitely determinable causes, precipitated into an accession of symptoms.

The relation of injury to a **recurrence** of a former ailment is also important, and this arises often in diseases of the nervous system, pelvic disturbances, and other more or less non-organic lesions that are normally characterized by a tendency to recur from various provocative causes. The neuroses (hysteria and neurasthenia) are in this group, as are also various tics, habit spasms, phobias, tremors, and even some mental disturbances.

Here, again, main reliance is to be placed on the nature and extent of the injury and the present manifestations as compared with the previous history of the recurring ailment. Special attention should be given to the duration and manifestations of the original condition, the interval in which there has been freedom from symptoms, and the medical verification, if any, of the claimed cessation or cure.

As many of these cases are rich in subjective and poor in objective symptoms, it will require more than the mere assertion of the patient to determine the exact importance of any accident as the sole factor in the alleged recurrence. The physician will, therefore, give careful scrutiny to this type of case and guard his opinion if the previous history is based wholly on the present narration of the patient. This caution is especially necessary in any case of alleged recurrence of female

pelvic disorders, such as uterine displacement or actual adnexal inflammation "due to a blow on the abdomen." Recurrent hernia also falls under suspicion, and likewise hernia appearing in postoperative scars.

The physician must in a case of this sort be in a position to answer for himself the self-propounded question, "Independent of the accident, would the present conditions appear sooner or later as part of the ordinary progress of the lesion?"

Criminal Cases

The physician is brought into contact with this group usually because of suicide, homicide, poisoning, infanticide, or abortion cases. The doctor's appearance may be required by the judge, district attorney, or coroner, and in this class of case it is very important that careful notes are available respecting every phase of the issue.

When a physician is called upon to attend a case of suspected criminal abortion, it is a wise procedure to have a colleague in consultation, so that no criminal responsibility or connivance by any chance may be falsely placed. If another physician is unavailable, a written statement should be obtained from the patient to the effect that the symptoms began before the arrival of the present physician and that the latter had hitherto not been in attendance. Such a statement should be obtained in the presence of, and signed by, competent witnesses. It is the height of folly for a physician to operate upon any such case without some precautions of this nature, and it is equally foolish to operate with any attempt at secrecy or without the assistance of a colleague, nurse, or attendant who is familiar with the proceedings undertaken. When feasible, patients of this class should be cared for in a hospital, because the publicity incident to such surroundings effectively precludes any charge of connivance or complicity.

Abortionists exist in all places, and their work is, as a rule, grossly unsurgical and almost brutally cruel, and patients treated by them are presumptively infected, if not more seriously damaged. I recently operated upon a woman who was sent to the hospital with a section of intestine hanging out of the vagina. This proved to be large intestine which had been pulled through a hole in the posterior vaginal wall where some instrument had been poked, doubtless with the idea that the uterus was being entered. Through this hole the loop of intestine had been dragged and cut off, evidently on the assumption that it was placental or other membrane, and, in addition, the mesentery of the sigmoid had been scraped so energetically that the blood-supply was entirely abolished. When the abdomen was opened the entire

colon was gangrenous, and it was excised and a cecosigmoidostomy performed. The patient lived only a short time.

Physical Examination of the Claimant

When a claim is made for damages due to an accident, a physical examination is usually requested by the interests being held legally responsible for the injuries. The attending physician is the proper person to arrange this, and such an examination should be made when feasible at the home of the patient or a doctor's office.

Railways and insurance companies have a regular printed form for such cases, and this is commonly known as the "surgeon's report." A typical form is shown on pages 728, 729.

At the time of the examination the examining physician first obtains the general history of the case from the patient, and then the medical history from the attending physician, and later proceeds with the examination, classifying the findings under regional headings. Any examination of this sort should be full and complete to be of value in rendering an opinion as to the nature of the injury and the probable duration in terms of total and partial disability, and also the extent of any deformity. An examination of the heart and blood-vessels should be included, and the main reflexes at least should be tested. It is important to look for hernia, flat-feet, varicose veins, and other deformities or disabilities, so that their relation, if any, to the injury may be determined. In the examination of women the pelvic organs should not be overlooked, and visceroptosis and kidney displacement must also receive attention. This latter condition, however, as hitherto indicated, is found almost solely in thin persons, and, indeed, a fat or protuberant abdominal wall precludes the possibility of palpating with accuracy a movable kidney. In women at or about the climacteric period, or in those who have had the menopause induced by operation or disease, it is quite important to determine what relation this may bear to any symptoms of a nervous or subjective type. The condition of the thyroid gland should be observed, especially if tachycardia is present.

It is unethical and unwise for an examining physician to discuss his findings with the patient or to criticize the attending physician either for improper diagnosis or treatment; and, in fact, the examiner must disclose his findings, opinions, and criticisms only to the interest engaging him, unless some arrangement to the contrary has been previously agreed upon.

In some cases about to be presented to a court and jury, the lawyer

for the patient may be represented by a physician who has examined the patient only for the purposes of testifying, and it is unfortunate for all concerned that the physician often selected for this purpose is usually better qualified from a legal than medical standpoint; and, indeed, the capacity of this sort of doctor is all too often based on court rather than clinical experience. I know several physicians of this stamp who glibly qualify as "experts" in practically any branch of

SURGEON'S REPORT.

Case of_____ Employed by, _____

Occupation,_____ Age,_____ Married or Single,_____

Residence,_____ Date of Accident,_____ 19

Name of Attending Physician,_____ P. O. Address,_____

DIAGNOSIS.	
PREVIOUS HISTORY	
PATIENT'S ACCOUNT OF ACCIDENT.	
IMMEDIATE EFFECTS OF ACCIDENT.	

Fig. 525.

PRESENT CONDITION AND PHYSICAL EXAMINATION	

Fig. 526.

RESULTS UP TO DATE.	
PROGNOSIS.	
REMARKS.	

Examined at ..... this ..... day of ....., 19

Signed, ... , M. D.
Examining Surgeon.

Fig. 527.

medicine and surgery, and yet their knowledge is gained almost wholly as examiners and not as clinicians. Such a doctor may have had little or no surgical or operative training, and yet his opinion may be entirely different from that of the attending or family physician, who speaks of what he actually knows and has observed, and not of what he has superficially culled from some text-book. I have heard doctors of this sort eloquently testify, for example, as to brain and intra-abdominal injuries, and yet they have scarcely seen the inside of a skull or abdomen since student days. Men of this grade would not be selected as family advisers or consultants by the patient, attending physician, or the attorney; but, nevertheless, their opinion is regarded as good enough for court and jury purposes. This practice is so flagrant that many physicians and surgeons of the best type hesitate to appear in any capacity in damage-suit cases, and if they treat the patient at all it is only on the proviso that they will not be called upon to appear in court.

On occasions the judge will appoint a physician to conduct an examination, the fee to be paid usually by the defendant, but sometimes by both parties. Such a "physician appointed by the court" is served with a "court order," and the examination is then made by the selected doctor, with or without a preliminary hearing before a court-appointed referee. At this hearing the court physician is at liberty to ask the patient any question that will elicit a complete past and present history, and then the actual physical examination is conducted in private. The questions asked and the replies given at "the hearing before the referee" form a part of the court records, and are usually read to the judge and jury at the trial, when the court physician may or may not testify. The latter immediately makes a report in writing to the court or judge, and these findings become a part of the records in the case and may often with propriety be amplified for either party in interest to whom the bill is rendered, and from whom a fee can be collected for court attendance or expert testimony. Such a formal report is usually worded about as shown on page 731.

In some instances this report should be sworn to before a notary public or commissioner of deeds, especially when the examination is made at a location distant from the place of trial. Unless specifically directed, the court physician is not called upon to express in his report any statement as to the future outcome of a given case, as that is regarded as expert testimony. Ordinarily one of the parties to the litigation will summon the court physician as a witness, and he will then have a right to render a separate bill for the added services, in effect becoming an expert witness.

To the Honorable Justice of the.....Court.

County of.....

Dear Sir:

Pursuant to your appointment I examined on.....at
(Date.)

.....,.....and found
(Place.) (Name of person examined.)

that he had sustained the following:.....
(Here name findings.)

.....

The remaining evidences are as follows:.....
(Here name existing signs.)

.....

.....

Respectfully submitted,

.....M. D.

The object of having the examination by such a "court appointee" is to allow the judge to make an impartial selection of the physician, but the latter thereby does not have any judicial functions conferred, nor is his opinion necessarily any more sacred or valuable than that of any other physician, and the party in interest paying for it has a perfect right to interview this court appointee before making him a witness.

Less often, during the course of a trial, both sides may ask the judge to appoint a physician to make an examination, and agree to have the appointee appear on the witness stand without making any report to the court or either party in interest; in such an event the physician is in duty bound not to disclose his findings or opinion until he testifies. Under these circumstances this physician is usually questioned first by the judge, and thereafter the lawyer for either side may ask further questions if desired.

In giving testimony, the physician is ordinarily first called upon to state his medical qualifications, and is then asked when and where he saw the patient and what he found upon examination. In naming his findings he must state the *objective* manifestations first, and then may or may not be allowed to relate the *subjective* complaints as they were stated by the patient. At all times the witness must bear in mind that he is talking to laymen who have little or no knowledge of technical terms, and if it becomes necessary to use a technicality, some simple explanation of the term should be given. The doctor should be fair, honest, and unbiased and do his utmost to present the facts as justly as possible. He must not weary the auditors with need-

less detail of no great importance, nor should be exploit his own skill or cleverness. He should be as willing to answer questions for one side as the other, and he must not indulge in sarcasm, repartee, or temper, for any such exhibition is undignified and will lend no value to his testimony. At times he may think his questioner does not know what he is talking about, and may even be tempted to tell him so; but the physician must not scold or lecture the lawyer, however great the temptation or provocation. Incidentally, it would be foolish, because the questioner would soon place the witness in a very uncomfortable and embarrassing frame of mind.

At all times the doctor must remember that he comes to court to fairly state what *he saw* and what *he did* in connection with the case at issue, and having done this he will be asked to give a statement as to the probable outcome of the injuries. At times the physician will be asked by the lawyer to answer "yes" or "no" to some question that does not properly permit of a categoric reply. In such a case the witness may respond, "I cannot answer that question by 'yes' or 'no.'" Under such circumstances the witness will then usually be allowed to answer the question in his own way; or, he may answer it "yes" or "no," and then state "I wish to qualify that by saying. . . ."

In testifying the doctor "will be allowed to look at his records to refresh his recollection," but he will not be permitted to read any extended account of the case, and, in fact, the written record is to be used only when the memory of the matter in hand requires to be refreshed.

The doctor may have hesitancy about disclosing some features of the patient's history or present injury; in such an event, the judge will usually direct the witness to answer fully as to any medical fact that might have a bearing upon the issue.

The question of "professional secrecy" is generally settled by the bringing of the suit, as the legal papers in the case usually indicate in more or less detail the actual nature of the physical ailments. The courts also hold that the plaintiff has no inherent right to call only the doctor desired or the one looked upon as most likely to give favorable testimony; but if one physician testifies as to the medical condition at issue, then any other physician may also be called upon, because the "plaintiff by calling one doctor has opened the door for the testimony of others . . ." and " . . . the seal of professional secrecy cannot be made at once a sword and shield. . . ."

This means that a dishonest litigant cannot, under the guise of "professional secrecy," seal the lips of a former physician who perhaps

was in attendance for the same ailment or injury that is now being testified to as being of recent origin by another physician ignorant of the original medical history.

After the physician has testified as to his findings, he is often asked a **hypothetical question** that seeks to embody all the essential facts in the case. Such a question usually begins with the words "Assuming that on such and such a date, . . ." and then follows an account of the manner of the accident, the symptoms, and the testimony as to medical findings. The ending of the question is usually ". . . now assuming the facts in the hypothetical question to be true, can you state with reasonable certainty whether or not an accident of the type described would or would not be a competent producing cause for the conditions you found?" To this question the physician replies, "I can state." Then the lawyer says, "Would it?" and the physician then states, "It would" or "It would not," depending upon his belief in the matter. The next question then is usually, "Assuming the same state of facts related in the hypothetical question, can you state with reasonable certainty whether or not the injury is or is not of a permanent and lasting nature?" The doctor replies to this, "I can state." The lawyer then asks, "Is it, or is it not permanent, with reasonable certainty?" To this the physician replies, "It is" or "It is not."

The doctor must answer the hypothetical question based only on the facts in that question, disregarding anything and everything else he knows or has heard of the case. The question is often the summation of the evidence in the language of the attorney, and the answer must be predicated only on the premises laid down in the question regardless of the physician's views in the matter. If, however, the premises assumed are medically incomplete, wrong, inconsistent, or perhaps absurd, the witness can with propriety state that he is unable to answer the question and may be given an opportunity to state why he cannot give an answer.

All such questions usually contain the premises that the litigant was (1) perfectly well before the accident; that (2) the accident occurred in the way related; that (3) certain symptoms followed and now exist; that (4) there has been no other intervening accident or illness. Assuming these foregoing to be true, the answer, of course, is inevitable that the accident caused the present conditions; but the vice and inherent flaw of such a question is that the witness is asked to assume as true what he knows to be false; hence, the careful and prudent witness should reply that he cannot answer a question of

that sort because some of the premises are medically impossible, improbable, contradictory, or inconsistent. The lawyers would legally denominate many of these questions as "irrelevant and incompetent," and certainly the same objections to them hold good from a medical standpoint.

The witness will not be allowed to speculate, guess, or surmise as to the probable outcome of a case; the opinion must be based not upon *absolute*, but upon *reasonable* certainty. This in many instances is practically the equivalent of stating what usually and ordinarily happens under a given set of circumstances. Similarly, the physician is not permitted to answer any hypothetical question calling for an opinion as to what "*could* happen" under a certain set of conditions, but the answer must be based on what "*would* happen."

The witness must exercise great care in expressing an opinion as to future permanency, especially if only a short period has intervened since the accident, and he also must have in mind the benefits that sometimes occur from a change of treatment, the care of a specialist, a new environment, and the cessation of litigation. This caution is especially necessary when the symptoms are, in the main, subjective rather than objective.

Cases that have a medicolegal bearing are very prone to breed more or less conscious exaggeration and malingering, and the experienced physician will soon find that claimants can be sorted into four groups, presenting:

(1) Actual injury with demonstrable symptoms—*the reality*.

(2) Actual injury with exaggerated symptoms—*the exaggerator*.

(3) Little or no injury with objective and subjective symptoms ascribable to other causes—*the malingerer*.

(4) Little or no injury with feigned objective and subjective symptoms—*the fakir*.

In other words:

Group one consists of wholly genuine cases.
Group two consists of partly genuine cases.
Group three consists of partly fraudulent cases.
Group four consists of wholly fraudulent cases.

Of these, groups one, two, and three are the most common in litigated cases, and it is noteworthy that subjective complaints are always most marked in patients treated out of hospitals, and also in those having relatively trivial injuries. A hospital stay does not usually afford much opportunity to develop suggested symptoms, and the association with patients who are actually hurt often has a salutary effect.

Since the Workmen's Compensation Law went into effect in this State (July 1, 1914) I have been impressed by the freedom from exaggerated claims, and ascribe this to the fixed payment rates for definite injuries and to the non-interference of a certain type of physician and lawyer. During the first twenty-six months of the operation of this law many thousands of employees were more or less injured in the various activities of the railways with which I am connected. Of this number, over 90 per cent. required one treatment only, and thus the very great proportion might have prolonged disability by asserting subjective symptoms if the proper motives existed. Of the more seriously hurt, comparatively few exaggerated to any great extent, and I recall but few whom we regarded as out-and-out fakirs. I know of but few cases in which marked traumasthenic symptoms developed.

By contrast with an identical group of injuries occurring under similar circumstances in men of a like station in life, this freedom from exaggeration and the neuroses is certainly very remarkable, and seems to give added basis for the belief that the traumatic neuroses are made for and not born of the patient.

Coroner's Cases

The law requires the physician to report to the coroner, or other designated official, any death occurring under unusual or suspicious circumstances, or any case of sudden death and those for which no adequate reason is apparent. All deaths from criminal sources or causes are also reportable.

The attending physician in such cases should make careful notes of his initial findings and all the circumstances surrounding the case, so that this information may be a matter of record and not of recollection.

If the physician has reason to believe a crime has been committed, he must exercise every precaution so that the cause of justice may not suffer by any act of omission or commission on his part.

When called upon to make affidavit or give testimony the physician must state only what *he knows and has observed*, and not *what he thinks or has been told*. Human life and happiness may depend on what he declares, and, therefore, he should "tell the truth, the whole truth, and nothing but the truth," leaving out any theory, speculation, prejudice, or preconception that he thinks fits the conditions better than the actual known facts.

Homicide and Assault Cases

In these the physician will always be an important witness, and, indeed, the measure of sentence may be directly dependent upon his testimony.

Careful records must be made of every detail of the occurrence, and these written notes, *made at the time*, will be much less subject to dispute at the trial than any recollection, however accurate it may appear to be.

If a *bullet* has been recovered, the physician must carefully preserve it, making written record of any marks on it due to instrumentation or search. The importance of this will be apparent when it is recalled that in many shooting cases the caliber and general appearance of a bullet may have an important bearing in fixing the guilt or locating the weapon.

In cases of suspected *poisoning* the odor of the breath and vomitus may be very important, and all excreta should be preserved in a clean glass-stoppered receptacle suitably sealed and marked for identification.

Death traceable to a *fractured skull* sometimes causes confusion if a fall has followed or has been occasioned by the original violence. Cases in which an apoplectic stroke produced a fall, which latter broke the skull, also come into this group. Most of these cases are cleared up by autopsy, and if a *central* and not a *cortical* hemorrhage is found, the physician may be reasonably sure that violence was not the sole originating factor however great the external evidences of injury may have been, for we know that no form of impact on the skull is able to produce deep-seated cerebral hemorrhage without also causing superficial hemorrhage. Uremic, epileptic, alcoholic, and other patients may fall and sustain fractures of the skull, and unless a complete examination is made the fall and not the source of it may be accused of responsibility. Simple attacks of giddiness or vertigo may accasionally act in the same way by causing a temporary loss of equilibrium leading to a fall or attendant injury.

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